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ANNALS of SURGERY

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THE VITALISTIC METHOD IN THE TREATMENT OF CERTAIN SURGICAL INFECTIONS

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AT THE Congress of the Italian Medical Society held in Bologna in 1917, I described a method of treatment of certain surgical infections with which I had obtained excellent results. At that time I gave a description of the method of application, and explained the elements which entered into the results obtained. I shall now try to give, a résumé of the underlying principles of this method of cure in its application, and the principal rules to be observed in applying the technic.

I shall treat of those infections in which the *local* phenomena are most dominant. It is true that no infection of a single part exists which does not show its effects on the whole body, but it is my intention to discuss those diseases in which a grave damage to the body economy is apparent, definite at times, yet more frequently confined to the affected region.

The method is founded, above all, on the production, by physical methods, of a convenient renewal of the blood corpuscles and serum in the region of the focus of infection, thus bringing into action those vital forces, which have the power not only of defense but also of restoring the infected region, hence the name: "vitalistic."

In the past, A. BIER reasoned that if it could be possible to artificially induce a state of passive hyperæmia in the region of an inflammatory reaction for a period of time, it would materially shorten the course of the inflammatory reaction. In a small part his assumption was correct, but in the greater part he was in error. In a previous pamphlet I pointed out wherein the German worker had erred, and I also mentioned that always new wealth of plasmatic and corpuscular energy which intercedes with its constant renewal, to develop within the focus the most valuable defensive and reparatory action which is due not only to the passive hyperæmia, but to the *whole* reaction of the circulatory phenomenon which is composed of both active and passive hyperæmia. It follows, therefore, that in order to obtain the true defensive and reparatory reaction it is not necessary to dissociate the circulatory phenomenon, but to have recourse to it by utilizing it *in toto*.*

Even to-day, in treating those diseases which will interest us here, I hold the opinion that if we wish to obtain the maximum reaction against many

* Schiassi: Tip. Orlandini, Modena, 1923, pp. 31–37.

local infections, we must have recourse to and utilize the circulation (hyperæmia); but we must not forget to utilize this factor *in toto*, in order that our artificial methods shall result in a maximum of efficiency. How can this be brought about? By utilizing thermal agencies. When these have given rise to an increase of the local corpuscular "population" by means of hyperæmization, they are capable of stimulating the metabolic processes of the region to a higher and more efficient activity. In addition to this increase in the corpuscular population, the plasmatic element is called into action to aid the processes of defense and purification. In order that the serum may act more

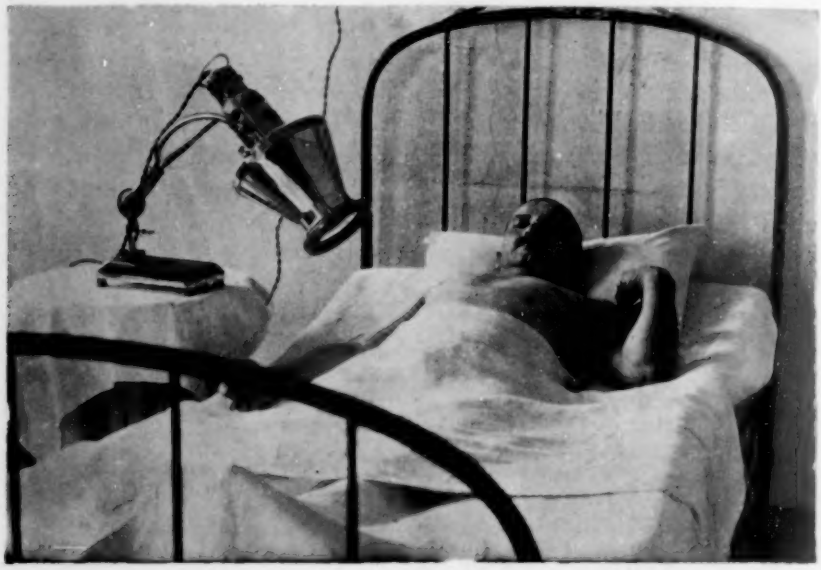

FIG. 1.—Venereal inguinal bubo, covered with a poultice sealed from the air, exposed to the heat of electric lamps placed at a distance of from 25 to 30 centimetres for from five to six hours daily.

favorably it is necessary that we provide means for the prevention of the least possible trace of transpiration of the part, thus accumulating a greater amount of serum in the region which, in bathing the underlying tissues, will result in a greater degree of purification. In this manner the combination of corpuscles and serum can act solidly and with intensity toward the realization of those energetic existing conditions capable of inducing that which I will designate as *zur strassen* or "over-production of opportunity." This will bring about the effect of a natural reaction which, although artificially stimulated, I may rightly call "*vital super-production.*"

We can make good use of hot baths. Some have thought that I make use of the bath according to the criteria of Langenbeck, Novaro, Strohmeyer and many others. This is not so; for these workers intended the bath as a purely antiseptic cure which would act from the exterior toward the interior of the focus. With my method I try, by physical means, to effect a cure which will indirectly act upon the microörganisms present, and to stimulate the vital forces of the body in such a manner that they will act from the interior

outward toward the exterior. Because of the foregoing reasons I hold that my method is of a character entirely different from the original intention of the workers mentioned.

The hot bath, maintained at a temperature of 38°–38.5°, has for its purpose:

1st. To bring to the affected region an increased number of those elements contained in the blood.

2nd. To provoke an influx of a great quantity of serum.

3rd. To excite the region to a more vivid histogenic defense. These are

FIG. 2.—Axillary adenitis; occlusive poultice; five lamps five to eight hours daily.

the main beneficial effects which I try to induce by employing the hot bath.

Beside the baths there are other means of secondary importance which I will mention as we proceed. These, together with the heat, are capable of stimulating into action the elements heretofore mentioned. These means, which are of positive benefit, should be applied in the manner which I shall describe. Hot packs or hot poultices, kept at a convenient temperature, heat-producing lamps can be employed, or some chemical rubefacient, etc., are other means which can be made use of for the aforementioned purposes.

The bath must never consist wholly of pure water because of the tendency of the tissues to become impregnated, thus provoking maceration. This occurs especially when, of necessity, the application of the bath must be protracted as in these cases. We can make use of an aqueous solution of sodium chloride made by dissolving 7.5 grams of sodium chloride in a litre of water. It is better to make use of a hypertonic solution, especially in open wounds, thus influencing them in the sense of producing an intense exosmosis from the infected region toward the solution and in this way obtaining an accentuated local purification with the expulsion of the noxious substances from the wound.

The hypertonic solution chosen by me contains the following:

Sodium chloride	8 grams
Potassium chloride	0.3 grams
Calcium chloride	1.0 grams
Sterile water	1000.0 grams

I have manufactured special appliances to fit the needs in a number of cases as follows:

Model A, for the hand, forearm, and elbow. Model B, for the arm.

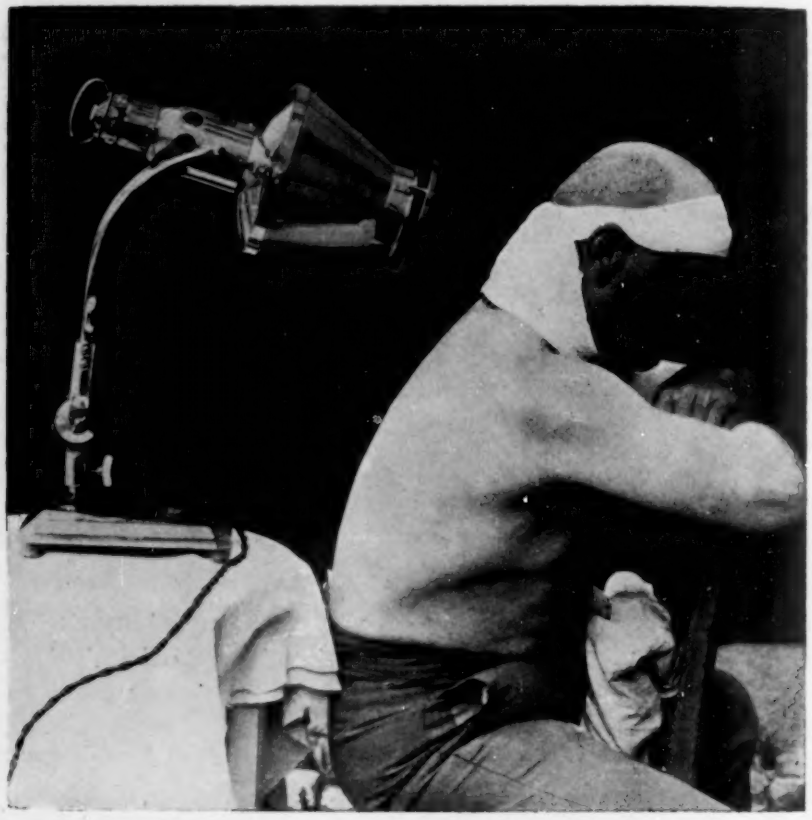

FIG. 3.—Carbuncle of the neck; occlusive poultice; five lamps six hours daily.

Model C, for the foot and leg. Model D, for the thigh, and knee. (See Figs.)

Each is furnished with an alcohol lamp intended for the maintenance of the constant temperature described.

Technic.—The duration of the bath must of necessity be of a long duration; I would suggest an average of from four to seven hours without interruption, as the case requires. The reason for this prolonged immersion of the part is that it will result in its purification, cellular invigoration, and histological defense, hence the production of new tissue. This process can only take place in a very slow manner because all formative-metabolic processes are of necessity slow.

When the part has been taken out of the bath it is advisable not to place gauze packs nor drainage tubes within the recesses of the wound, but to simply place either a piece of gauze or other hydrophyllic substance on the surface of the wound itself. When proceeding to the bath it is necessary to remove the bandage and the superficial layer of gauze only; the gauze which is in contact with the wound is left in place. The part is then immersed into the bath together with the adherent gauze. Because of the dissolving action of the liquid upon the exudates adhering to the gauze, and in part, to the expulsive

FIG. 4.—Otitis media with mastoiditis; occlusive poultice; five lamps six to seven hours daily.

action of the noxious substances which tend to exude from the wound, the gauze will gradually detach itself from the wound. This process of detachment can be aided materially by the patient in exercising rhythmical movements of the part or by the contraction of the muscles. The temperature of the bath must be maintained constant between 38° C. and 38.5° C. Lower temperatures would render the bath inefficient while higher temperatures would prove noxious for more than one reason. Therefore it is necessary to exercise a continued and scrupulous vigilance regarding this point for the hot bath, when prolonged, tends to induce a deep anæsthesia of the immersed part. When this occurs, the patient unaware of the rise in the temperature, may subject himself to scalds.

Very often the patients will learn when to extinguish or to relight the lamp beneath the bath.

The bath is practiced daily. In the interval between baths the part, dressed, as I mentioned, with absorbent material, is kept in an elevated position. The upper extremity may be placed in an inclined position with the aid of pillows, on the other hand, the lower extremity may be held with the aid of Zuppingers apparatus.

Hot Packs, Poultices.—A malignant pustule, an adenitis of the neck or axilla, any focus located in the trunk or abdomen, as acute colicystitis, appendicitis, salpingitis, arthritis of the shoulder or hip, otitis, mastoiditis, especially during the first few days of their incipiency, are usually benefited by the application of hot packs or poultices. We must make use of these means because the location will not permit us to make use of the bath appliances with any degree of facility.

The hot packs, as well as the poultices must not be applied according to the

FIG. 5.—Appendicitis in its first stage; occlusive poultice; five lamps five or six hours daily.

ancient empirical criteria, if we wish to obtain the desired efficiency, but in accordance with the vitalistic criterion of "*always new, vivid, and prolonged renovation of blood and transudation within the infected region.*"

My experience authorizes me to assert that the following is a good technic worthy of application:

Packs.—Several folds of linen or woollen cloth are placed on top of one another and immersed in hot water (38° C.–39° C.), they are then lightly squeezed in such a way that the texture will retain the greater part of the water. The folds should be of such dimension sufficiently wide to cover the region desired, this is then covered with a piece of impermeable material preferably rubber † large enough to cover the pack with a margin of two or three inches in width, over and above the dimension of the pack. This is followed with bandaging the part in such a way so that the rubber material will closely adhere to the skin around the margins of the pack so as to close the pack within, cover the affected region, thus making the region absolutely impermeable.

† There are sheets of rubber on the market which are not of good enough material to fulfill the conditions required, therefore it is best to obtain a sheet of rubber which will insure absolute impermeability.

Over this dressing an electric heater is applied, or the rays of a heating lamp are allowed to converge upon it uninterruptedly for 5 to 7 hours.

Poultices.—The poultice is a more efficacious agent, more so than the packs, because it is a means with which we are enabled to enclose the affected area within a warm and *impermeable space.* It should not be necessary to repeat that the poultice is not applied as an *emollient* in accordance with the

FIG. 6.—Furuncle on the upper lip; impermeable poultice applied; lamps with diaphragm five to six hours daily.

idea of the old therapists. We are trying to *induce a continued stream of new blood and transudates* within the infected area.

Linseed may be used to advantage for the poultice or else some other substance rich in oleoses. A little olive oil may be added with advantage so as to render the paste more efficient in holding the heat for the required time.

The poultice should be of a thickness ranging from 2 to 3 cm., and of sufficient width to cover the desired area. It should be applied as hot as is reasonably possible. As with the pack, it is then covered with a sheet of impermeable rubber and bandaged in a manner analogous to the pack taking

care to make the area within air-tight. Over this is placed an electric heater, or better, the rays of a lamp are directed upon it.

I have employed the so-called "*Sollux*" lamp of Hanau, having a 2000 candle-power. I place it at a distance ranging from 20, 30, or 35 cm. from the desired focus.

If the area to be heated is located on the face, I would advise smoked glasses for the patient in order to protect his eyes from the rays, and with the

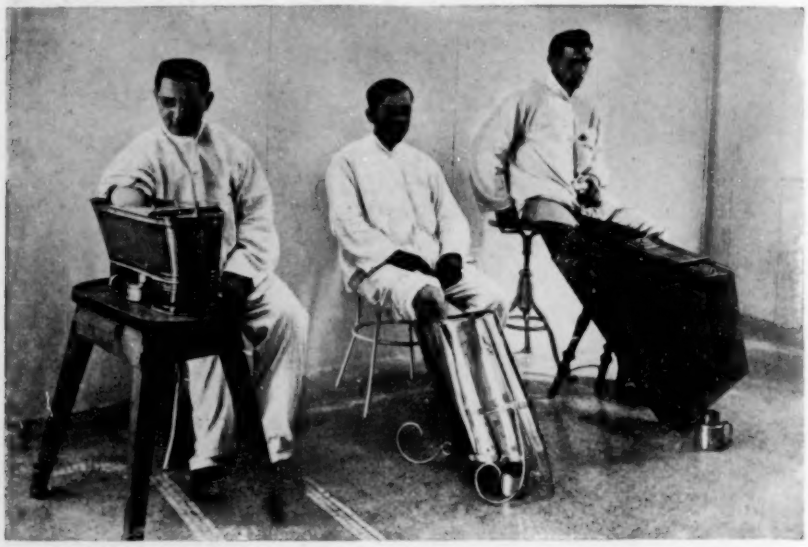

FIG. 7.—Apparatus for administering prolonged baths to the upper and the lower extremities.

aid of opportune diaphragms, annexed to the lamp, I try to direct the rays strictly upon the area desired.

I believe it is a favorable practice not to go beyond the stipulated set time (6–7 hours) of this treatment be it with the bath, hot pack, or poultice. Convenience will decide other repetitions of the treatment in the same or on successive days. But as a general criterion, I believe it will be better, after one treatment, to wait 12–15 hours, according to the discretion of the surgeon, before the next succeeding treatment. To follow this routine is good practice because, in the interval, the liquids which have infiltrated the lacunar spaces of the region are reabsorbed, the skin enclosed within an impermeable space, is placed under its natural respiratory conditions, and the blood and lymphatic vessels, especially those contiguous to the affected area, will acquire their normal tonicity.

Results.—The observed facts, running through a period of years of work with this method, authorizes me to state that without any doubt no work exists which treats of many acute local infections. Such a work would be of benefit to us all, especially so in their incipient stage.

The attenuation, and often, the cessation of pain means comfort. In such cases as gonococcal infections of joints, a phlegmon of the hand or a carbuncle

in the nuchal region, the application of the hot bath or poultice, when applied according to the directions herein described, will result in the diminution or entire elimination of pain.

I believe that the anæsthetizing phenomenon occurs in the following man-

FIG. 8.—Phlegmon of the hand which has already been incised to facilitate the expulsion of discharge. The plate shows the form of bath useful for promoting local exosmosis and later restoration to normal.

ner: the physical agent, *heat,* causes a great influx of blood into the part, it follows that there will result a serous infiltration of the tissues; the immersion of the part in water or the absolute occlusion of the region with an impermeable substance. This will impede transpiration thus the imbibition of the

tissues will be maintained at the high degree. It follows that the nervous elements, surrounded by the liquid, will lose their capacity of transmitting the painful stimuli.

The phenomenon is so prominent in the regions immersed in the bath,

FIG. 9.—Shows the method of cure for an infected lacerated and contused wound of the foot. Bath to be used from six to eight continuous hours daily.

where transpiration is absolutely abolished, that I have had double bottoms constructed in my apparatus for the reason that the patients did not notice the rapid rise in temperature of the bottom of the pan. This often resulted in very bad burns of that part in contact with the bottom of the pan. I have observed,

at times, very bad burns, because the patient had not noticed it during the bathing of the part.

A slight anæsthetic effect can be obtained with the application of electric heaters, hot packs and poultices, without inclusions but impermeable. But if

FIG. 10.—Shows treatment of burns of the lower third of the thigh, of the knee, and leg. Bath to be used from five to six hours daily.

we wish to utilize these methods, we must do it in a manner that the region desired be *hermetically* sealed. In this case the hot packs and poultices will approximate, in their anæsthetizing action, the hot bath. For this reason I am compelled to recommend with insistency that, when employing the hot packs

or poultices, they be applied with particular attention to their absolute *impermeability*.

The patients derive so much relief from pain through the application of the hot bath, packs or poultice, that they often ask to shorten the interval between each successive application. It is always advisable to allow a period of time between applications, because during this interval those modifications which I have mentioned, the reabsorbing of the serous infiltration, occurs. This event puts the affected region in the proper condition for the collection of a new quantity of serum during the next succeeding application of heat. All this is in conformity with the principle of the method, that is, to bring to the part an ample supply of fresh blood and serum which will remain therein for a period of time.

The method is indicated in treatment of local infections, both in the incipient as well as in the developed stage. It is also indicated during the exudation stage until the process has directed itself toward its cure.

In the first phases, beside attenuating or eliminating the pain, it activates the organic reactions toward the elimination of the pathogenes. The exudates are quickly augmented and the inflammatory reaction soon subsides.

The surgeon may deem it necessary, in some cases, to intervene with surgical means in order to give free exit to collections of toxic substances, care being taken to isolate from the surrounding anatomical elements, that part which has been impaired. The surgeon, therefore, must apply the method with good judgment and continued watchfulness, in order to intervene promptly with the knife where he sees that it is necessary to apply surgical therapy in conjunction with that therapy which I have called "*vitalistic*." The surgeon should not insist upon surgical therapy only, especially in phlegmonic infections of the deep tendon sheaths, hyper-acute cholecystitis, dangerous infections of the neck, pyo-arthritis of the knee, or in an acute poliomyelitis in an adult. He should have the clinical capacity to judge the proper time to apply the vitalistic method in each case, also the how, when and where to employ operative measures. Later, applications of the method may be continued, especially in those regions where the bath is applicable, in order to stimulate restorative processes.

Summarizing the method, according to what has been said, is very efficient, hence it is indicated in all painful affections, that is to say, in cases of contusion, distortion, and other painful affections which have a local origin. The method is applied, in accordance with the criteria put forth, in local infections, among which I mentioned phlegmones, arthritis, malignant postule, infected wounds, otitis, mastoiditis, in some cases of appendicitis, salpingitis, etc., etc. The method is valuable in labor accidents in order to reduce to a minimum the consequences of lacerative, contusions, and infective lesions with a therapy which brings the quickest results in providing for the defense and reparation of the tissues.

ON SIMPLE AND COMBINED LIGATIONS OF PULMONARY VESSELS*

AN EXPERIMENTAL STUDY

By Sergius A. Smirnof, M.D.

of Tomsk, Siberia

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PROFESSOR A. A. OPOKIN, DIRECTOR

In connection with the general progress of the surgery of the lungs the vascular tubes have come practically into the field of surgical intervention. Some operations upon the pulmonary vessels have already been performed in clinical work.

Thus, Trendelenburg and others have made arteriotomy on account of the emboli of the pulmonary artery. Sauerbruch, Willy Meyer and others have ligated this artery on account of bronchiectasis. Eiselsberg has put a suture in the pulmonary vein. Heyle has ligated the pulmonary vein on account of gunshot wound.

However, to obtain the rights of citizenship in clinical practice, an operation on the pulmonary vessels should have some reasonable experimental foundations. It must be said that the question of the ligation of the pulmonary vessels is far from being experimentally worked out. At the present time we have some data only concerning the ligation of the pulmonary artery and its branches, the narrowing of the pulmonary vein according to Tigel and data concerning the ligation of the pulmonary vein.

Nothing is as yet known of the results of the combined ligations of the pulmonary vessels. So I undertook the task of studying the results of operative intervention in the pulmonary vessels. Since 1920, thirty experiments on dogs have been carried out, including isolated ligations of the branches of the pulmonary artery and vein as well as the simultaneous ligations of these vessels; I ligated also *en masse* the bronchial vessels and at the same time the bronchial vessels with the pulmonary artery and vein.

These experiments resulted in some interesting findings both as regards the explanation of the intra- and extra-organous circulation of the blood in the lungs, and as regards the post-operative pathologo-anatomical alterations ensuing in the parenchyma of the lungs. It is by the tying some or other vessels of the lungs that may be produced an essential disturbance in the pulmonary blood stream, stimulating the organ to reveal the power and the character of its collaterals, which thus compensate the disarrangement of the circulation of blood. On the other hand, we make the lung to reveal those reactive changes in the parenchyma which result in the perversion of the normal circulation of the blood.

Let me begin with the ligation of the pulmonary artery.

* Read before the 16th Congress of Russian Surgeons, Moscow, May 13, 1924.

In ligating the pulmonary artery or its branches we exclude the whole of the lung or its lobe from the lesser circulation and shunt it to the greater circulation.

Hence by means of this operation we deprive the lung of the venous blood and remove its respiratory function. But the blood circulation in the pulmonary artery below the ligature is always reëstablished at the expense of the collaterals and the bronchial arteries. The existence of these collaterals has been demonstrated by many authors (Renseisen, Zuckerkandl, Landlois, Jores). However, they failed in filling these collaterals by means of injections through the pulmonary artery, aorta and bronchial arteries. Neither were my attempts in that direction successful. The radiographs presented but some conception of the course of the normal ramifications of the mentioned vessels in the lungs.

To elucidate the question of the bronchial collaterals of the pulmonary artery I undertook the following experiments:

1. After tying preliminarily the pulmonary artery I made an opening below the ligature. Instantaneously the arterial blood flew out of the incision. Further on, I isolated the bronchus together with the vessels and tied it round with the ligature. The bleeding stopped rapidly. The removal of the ligature from the bronchus was again followed by hemorrhage out of the incision of the pulmonary artery.

2. Under analogous conditions. I introduced intravenously a 10 per cent. solution of yellow blood salt. I found a clear reaction of the Berlin blue in the blood obtained from the incision of the pulmonary artery below the ligature and treated with ferrum sesquichloridum.

3. In injecting the 10 per cent. solution of the yellow blood salt into the pulmonary artery I obtained in a few seconds the reaction of the Berlin blue from the blood of the peripheral bronchial vessels (the central part of the bronchus and the vessels were tied with the ligature).

4. Ten days after the ligation of the branch of the pulmonary artery of the lower lobe I found that its whole lumen below the ligature was occupied by coagulated blood. (The animal perished of pneumothorax, owing to the rupture of the wound.)

5. Our pathologo-anatomical investigations of the whole series of permanent experiments with the ligation of the branches of the pulmonary artery show the considerable dilatation of the bronchial arteries during this operation.

It results evidently from these experiments that the pulmonary artery has really powerful collaterals with the bronchial arteries that are able to distend the whole aperture of its ramifications as far as the ligature.

Furthermore in forming adhesions with the parietal pleura and the environing organs the lung has a tendency to produce extra-organous collaterals by means of the developed adhesions. The fact of the development of the vessels in the adhesions has been experimentally proved by Kawamura and myself, also by Melnikoff, by means of injections in human cadavers which were the subjects of adhesive pleuritis. It should be noticed moreover that the develop-

ment of the collaterals through adhesions with the correlative vessels of the neighboring lobe of the lung as a rule has not been observed.

In the pathologo-anatomical respect the disturbance of the blood circulation in the lungs by means of the ligation of the branches of the pulmonary artery leads to the fibrotic atrophy of the organ, its functional ruin, destructive changes in the bronchi and sometimes to the development of cystoid cavities in the parenchyma of the lungs. For this reason the operation at present cannot, in my opinion, have any clinical future, although it was known to have been performed on men by Sauerbruch and Willy Meyer.

In isolated ligation of the pulmonary veins or their lobular branches a different picture has been observed. In this case we forcibly stop the arterial blood from running off into the left lung. Under these conditions the blood may run off only into the right half of the heart through the bronchial veins. If these collaterals are adequate the circulation of the blood may of course become more equally distributed, otherwise the phenomena of stagnation shall inevitably ensue with all their heavy consequences. With dogs these collaterals are as a rule inadequate although the anastomoses among the branches of the lobular veins are distinctly expressed. Accordingly, in ligating the pulmonary veins in dogs the schematic bath of blood, after the expression of W. A. Oppel, is overfilled and the phenomena of transudation and dropsy occur. My experiments in this respect fully correspond with the findings of Bruns and Sauerbruch, who came to the conclusion that such operations could not be performed since in the course of several hours after ligation of the vein a sharp dropsy of the lung takes place. I do not mention here the narrowing of the vein with wire, according to Tigel, these experiments having no practical value.

Under clinical conditions the isolated ligation of the vein of the lower lobe of the left lung was made by Heyle on account of gunshot wound with a favorable result. However, from the standpoint of experimental data this operation should be subjected to further control. The same experimental data on animals speak for the necessity of putting the vessel suture upon the vein in the case of its being wounded, as performed clinically by Eiselsberg, although his patient succumbed from empyema.

If for any reason suture of the vein cannot be imposed the pulmonary artery, as my experiments show, must be necessarily tied at the same time as the vein.

The question of simultaneous ligation of these vessels has not been entirely worked out till now.

In experimenting with the simultaneous ligation of the pulmonary artery and the vein of the inferior lobe of the left lung in the dog I obtained the following results: the animals stood the operation well. Further on, on the thirty-sixth and forty-first days after operation shrinkage of the lobe of the lung has ensued, causing decrease in size, solidification and pretty nearly full airlessness. The lobe of the lung adheres to the pleura and the environing organs.

A microscopical study has shown a typical picture of the fibrotic atrophy with the clearly distinguished bundle-shaped development of the connective tissue, the compression of the alveoli, the shedding and destruction of the respiratory epithelium and the formation of vicarious emphysematous cavities. The pulmonary veins are distended. The environing cellular tissue is slightly œdematous. The bronchial veins are dilated. The bronchi are greatly distended. Their mucous membrane is atrophied here and there. The muscles of the bronchi are partly atrophied, partly broken off. Here the picture of the alterations in the bronchial tree is quite different from that in the ligations of the branches of the pulmonary artery. Functionally the lung perishes as well.

It is perfectly evident that the circulation of the blood in the lung can be reëstablished under the present conditions solely at the expense of the collaterals and the bronchial vessels. Indeed, the yellow blood salt introduced into the greater circulation produced, when dissolved, the reaction of the Berlin blue in the blood of these vessels below the ligature. Therefore the "reduced" (according to expression of W. A. Oppel) blood current is formed in the lungs. Through the bronchial collaterals the blood enters the ramifications of the pulmonary artery and runs off from the pulmonary vein through the bronchial veins. But since the current of the blood to the lung through the bronchial vessels at one unit of time in that case will be less than when the pulmonary artery is open, the favorable conditions for the venous collaterals are virtually created. The inadequate venous collaterals develop adequate ones, the blood stream becomes more even and the animals survive.

The experimental data lead consequently to the conclusion that in the case of lesions of the pulmonary vein the artery must be tied at the same time. Such operation has not yet been carried out in clinical practice.

It is furthermore interesting to bring out what will happen when the bronchial arteries and veins are ligated. It should be said, however, that for some anatomical reasons, *viz:* abundance of the anastomoses of bronchial arteries of œsophagus, mediastinum, pericardium, arteria intercostales, etc., the full stoppage of the blood in the bronchial arteries is impossible. The data of the Bruns and the Sauerbruch experiments entirely agree with this. Their efforts at tying isolately all the bronchial arteries failed. For similar conceivable reasons, it is impossible to ligate all the veins. Consequently there remains the only possible way that is to tie all the arteries and veins *en masse* on the bronchus itself, narrowing its aperture to the degree of the cessation of the circulation of the blood in its vessels. After having ascertained preliminarily by injections into cadavers the possibility of the interruption of the blood current in this way, I have experimented on dogs. The dogs proved to bear this operation well. When they were removed from the experiments after 7, 10 and 32 days, it has been found that the lobe of the operated lung was slightly collapsed, but the pieces of it floated in water. The lung is adhered to the pleura solely at the place of its incision. There are no adhesions to the adjoining organs and the neighboring lobe. The ligature in the bronchus

is wrapped in a solid cover of connective tissue. The bronchus has the shape of an hour-glass.

In the microscopical examination the alterations of the alveolar cavities in shape and size are displayed as well as the considerable development of the connective tissue in the alveolar walls and their solidification. The respiratory epithelium is preserved. The form of bronchi and the mucous membrane do not exhibit any particular deviations from the normal. Hence it is clear that the bronchial arteries, although considered as vessels, nourishing the pulmonary tissue, nevertheless are not absolutely necessary for the life of the bronchi and the pulmonary tissue.

It is to be believed that on account of the permanently changing conditions of the pressure in the pulmonary vessels at inspiration and expiration as well as through the systole and diastole of the heart the pulmonary vein assumes the compensatory function of the nutrition of the lung. This nutrition proved to be sufficient to prevent the physical death of the organ as a whole or in part.

This experimental fact throws light upon the details of the physiology of the nutrition of the pulmonary tissue in cases of disturbance of the circulation of blood in the bronchial vessels.

That the compensatory nutrition of the pulmonary tissue is produced actually at the expense of the arterial blood of the pulmonary vein, and not any other vessels, is demonstrated by my own experiments with the simultaneous ligation of the pulmonary vein and bronchial vessels, from which the gangrene of the lung occurs.

The same pathologo-anatomical effect, that is, the gangrene of the lung, is obtained when the pulmonary artery and bronchial vessels are ligated simultaneously.

Thus by interrupting the circulation of the blood in the lungs by means of the simple and combined ligations of their vessels we have obtained the corresponding pathologo-anatomical alterations in the tissue of the lung beginning with the fibrotic atrophy of it and ending with the gangrene of the whole of the lobe of the lung.

It is interesting to emphasize that both after the isolated ligation of the pulmonary artery and the simultaneous ligation with the vein, some sharp alterations of the bronchial tree are obtained, but of the opposite character: in the former case—hypertrophy, and in the latter atrophy.

The development of the connective tissue of the lung when the artery alone is tied takes place more proportionally than when combined with ligature of the vein, at which its proportional overgrowth with the formation of the bundles is obvious at once. In the ligation of the bronchial vessels the outgrowth of the connective tissue goes also more or less proportionally but with its predominant development in the alveolar walls, whereas in the bronchial system on the contrary no sharp alterations occur.

The control of the equalization of the blood current in the lung at the various ligations of its vessels at the moment of the operation entirely falls

on its intra-organous collaterals when the lungs are free. Only after later development of adhesions can extra-organous collaterals be formed also.

Summing up, I submit the following conclusions.

CONCLUSIONS

Operations involving simple and combined ligations of the pulmonary vessels:

1. Bring out the system of the intra-organous collaterals in the lung.
2. Manifest the nature of the successive pathologo-anatomical alterations in the parenchyma of the lung.
3. Throw light on some details of the physiology of nutrition of the pulmonary tissue and bronchi.
4. Give the key to the understanding of one of the etiological steps of gangrene of the lung.
5. Help in bringing out the indications as well as the contraindications for performing ligations of the pulmonary vessels in clinical practice.

LUNG ABSCESS *

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It is proposed in this paper to review our knowledge of lung abscess which has increased so markedly in recent years owing to the X-rays, the bronchoscope and more frequent operation.

Etiology.—Pyogenic infection may be brought to the lung in one of five ways: by the air passages, from contiguous structures, by the blood, by the lymphatics or direct through wounds. Although we are constantly inhaling large numbers of bacteria, many of them undoubtedly pyogenic and in other ways pathogenic; the bactericidal action of the extruded epithelium, leukocytes, mucus, serum, etc., and the ciliary activity of the air passages prevents ingress or pathogenesis unless the tissues be weakened by general debility, previous local disease, injury, or by other factors as yet undetermined. Foreign bodies in the air passages, suppurative processes in or around the larynx, trachea or larger bronchi, deglutition pneumonia, in which from altered innervation, food particles gain ingress to the air passages, may all give rise to abscess formation by depositing an irritant, no matter how small, and with it the bacteria of suppuration.

Pneumonia, particularly broncho-pneumonia of the influenza type, may give rise to lung abscess. Localized or circumscribed empyema, particularly when situated between the lobes or at the base between the diaphragm and lung, may penetrate the pulmonary tissue by a gradually extending infection and necrosis and eventually find evacuation through a bronchus. Abscess of the liver may perforate the diaphragm and infect the lung. Mediastinal abscess and other forms of peripulmonic suppuration may likewise induce suppurative pulmonic lesions. Cancer of the œsophagus may lead to direct infection of the lung tissue or of the air passages.

The frequency with which lung suppuration follows tonsillectomy cannot fail to arrest attention. While there is some difference in opinion as to the pathway of infection in these cases, it is pretty generally conceded that many take place through the aspiration of foreign material and organisms from the upper respiratory tract. These cases, then, are in many instances bronchogenic in their development, the finer bronchi probably being plugged by the aspirated foreign material act as test tubes for the multiplication of the bacteria of suppuration. In a certain percentage of cases infection is unquestionably direct from the lacerated tonsil bed through the lymphatic or blood-vessels.[1] Just how often this occurs of course is mere conjecture. Moore,[2] in an analysis of a series of two hundred and two cases of lung suppuration following operations about the upper respiratory tract, found that one hundred

* Read before the Buffalo Academy of Medicine, Section of Surgery, Nov. 4, 1925.

and fifty-nine of them followed operation under general anæsthesia and thirty-nine under local anæsthesia. The fact that the vast majority of post-operative cases follow general anæsthesia has been pointed out by many authors. Under general anæsthesia the cough reflex is of course abolished so that infected material can gain easy ingress to the air passages, as Jackson says the cough reflex is the watch-dog of the lungs.

Myerson [3] examined a hundred patients upon whom tonsillectomy had been performed under general anæsthesia, making a direct examination of the larynx and trachea after bleeding was entirely controlled and found blood in the trachea and bronchi in seventy-nine of these cases. Once foreign material has reached the periphery of the lung, upward drainage depends chiefly on the action of the cilia. When one considers the fact that the mouth and throat contain innumerable bacteria of various kinds, it is surprising that lung abscess does not follow tonsillectomy under general anæsthesia more frequently. Moore estimates that pulmonary suppuration occurs once in every twenty-five hundred to three thousand tonsillectomies.

Lord,[4] in a recent paper, analyzed two hundred and twenty-seven cases of pulmonary abscess. In this series 34.3 per cent. could be traced to operation about the respiratory tract. "Tonsillectomy was responsible for the largest single group; forty-nine cases, including six in which it was combined with removal of adenoids and two with a nasal operation. The extraction of teeth accounted for twenty-one cases. An operation for cancer of the jaw, tongue or lip, drainage of peritonsillar abscess, nasal operations alone and adenectomy alone were concerned in eight cases. Eighteen further cases were ascribed to operations under a general anæsthetic, making a total of forty-two per cent. referable to a preceding surgical procedure." There were 49.7 per cent. traceable to the aspiration of infected material in one way or another, from the upper respiratory tract "or occurring under such circumstances as to make it reasonable to assume that the abscess arose in consequence of access to the lung of material derived from this region." Of the remaining cases in this series of two hundred and twenty-seven which Lord analyzes, 33.4 per cent. had an insidious onset and the cause was undetermined. In 12.3 per cent. the onset was stormy and suggested a relation to pneumonia, but the evolution and grouping of the initial manifestations did not indicate pneumonia in more than a few instances. Of the few remaining cases metastasis of bacteria with or without embolism and infarction may have played a part in eight and extension from abdominal or pleural suppuration in two.

Lord says: "In both the post-operative and the non-operated group pulmonary abscess arises so frequently apart from lobar or obvious bronchopneumonia as to suggest that it is to be regarded usually not as an accident of resolution, as ordinarily believed, but as an independent infection due to the aspiration of putrefactive organisms into the deeper parts of the respiratory tract."

On the other hand, Norris and Landis,[5] in an analysis of thirty cases of lung abscess give pneumonia as the primary cause in nine. They also lean

towards the embolic hypothesis as an explanation of post-tonsillectomy abscess. Wessler [6] ascribed pneumonia as an etiological factor in thirty-seven out of one hundred cases. Among the less frequent causes may be mentioned direct trauma such as gun-shot wounds and stab wounds. Lung abscess occurs three times as often in males as in females. It may occur at any age, but is most common between twenty-five and forty years of age.

Pathology.—Lung abscess may be single or multiple. Both types affect the lower lobes most often. The majority of cases of multiple abscess are embolic from suppurative foci often at distant parts of the body, although they may follow pneumonia or the aspiration of foreign material. The right side of the chest is involved three times as often as the left. Wessler states that there is a distinct difference in the localization of abscesses following aspiration of infected material or emboli and those following pneumonia. He finds the upper lobes involved twice as often in the post-operative or aspiration type; the exact reverse in the chronic post-pneumonic type. He also speaks of an acute post-pneumonic type which involves the upper lobes more frequently than does the chronic. Moore found involvement of the lower lobes in sixty per cent. of the cases in his series. In Wessler's series, post-operative abscesses in children invariably were situated in the upper lobes.

The pathology is varied. The lesion begins in the bronchi, in the parenchyma of the lung or in the blood-vessels according to the etiological factor. The usual inflammatory reaction is seen. The involved area is gray, yellow or reddish-yellow in color and on section is filled with yellow or reddish-yellow pus. If progressing, later there is a wall of soft necrotic lung tissue surrounded by an area of intense hyperæmia and œdema and perhaps in the centre a cavity of small or large size. Very often there is a sweetish odor to the pus or it may be very foul. The majority of abscesses develop in the peripheral portion of the lung. They may, however, develop in the hilus or the central portion of a lobe. If peripheral, the overlying pleura shows cloudiness and congestion, and as the process develops adhesion between the pleural surfaces takes place. Enlargement of the bronchial glands is usually present. (Lockwood.) The bacteriological findings vary. The most common organisms are the staphylococcus, streptococcus and the colon bacillus. Various anaërobes may also be found. Lambert and Miller [7] studied the bacteriology in ten cases of lung abscess in which examinations were made directly from the abscesses at the time of operation. The striking feature of this study was the uniform presence of anaërobic bacteria which were present in predominating numbers in all and were the only type of organism found in eight of the ten cases. They found streptothrix in six cases, a Gram-positive coccus in six, a Gram-positive bacillus in four, a Gram-negative bacillus in seven and a fusiform bacillus in two cases and a spirillum, closely resembling that in Vincent's angina in one case. They "have attempted some preliminary experiments with monkeys in an endeavor to produce lung lesions by intratrachial injection of these anaërobic organisms and in one monkey this was done in conjunction with tonsillectomy. The animals reacted with some

fever for a few days but no lung lesions were produced." Bronchiectasis to a greater or lesser extent coexists with lung abscess. If the abscess has existed for some time, connective tissue develops in its wall and the neighboring bronchi become chronically inflamed, obstructed and dilated. New abscesses may form with new zones of inflammatory reaction. Fibroid changes take place in the adjacent lung tissue.

A single abscess usually ruptures into a bronchus and thus establishes drainage, the necrotic material and pus being expectorated. If drainage is adequate the surrounding inflammation gradually subsides, the lung expands and obliterates the cavity and the tissues heal, leaving nothing but a fibrous scar. In such cases the cure is accomplished within a few months of the onset. "Less than one-fourth of the acute single abscesses require surgical intervention." [8] The abscess may rupture through the pleura, thus causing a pyopneumothorax, or if limiting adhesions exist, an extrapulmonary abscess. Such an abscess may be encysted in an interlobar fissure, between the base of the lung and the diaphragm or between the lung and chest wall. The abscess may become chronic, initiating extensive fibroid changes in the adjacent lung tissue or the development of bronchiectasis or new foci of pulmonary suppuration.

Prognosis.—The etiology has a decisive and direct bearing on the prognosis. The post-operative cases are the most favorable. A fair number of post-tonsillectomy cases recover spontaneously. The disappearance of symptoms and signs, however, must not be regarded as a cure, as X-ray examination will often reveal a smoldering area of infiltration that may at any time be rekindled. The early stage of lung abscess is characterized by deceptive remissions which make prognostication hazardous. If of foreign body origin, pulmonary abscess almost invariably heals after the removal of the object and a régime of fresh air and rest, without local measures of any kind. The prognosis, of the post-pneumonic cases, appears to be less favorable. Abscesses following broncho-pneumonia are apt to be multiple and for that reason have a high mortality. Upper lobe abscesses are more favorable than those located in the middle or lower lobes. The prognosis is better in acute than in chronic cases, in single than in multiple. In metastatic abscesses the prognosis is usually bad. Much depends on the individual resistance of the patient, the virulence of the organisms, the early recognition of the condition, the prompt and proper selection of treatment. Throughout the course of the disease, there is a shadow of complications more serious than the disease, the principle of which are brain abscess and pulmonary hemorrhage.

Symptoms and Diagnosis.—The symptoms vary with the cause of the disease and with the stage. In the case of aspiration abscess, Wessler states that foul expectoration begins about the fourteenth day. In cases due to pneumonia or embolism from foci at distant parts of the body, the evidence of development of pulmonary suppuration may be hidden by the constitutional symptoms and signs of the primary disease. The development of foul

expectoration following in the wake of operation or in the course of a disease should at once arouse suspicion. Foul breath and foul sputum are very constant signs, although lung abscess in rare instances occurs without either. Malaise, fever of the septic type, chills, sweating and pain in the chest usually occur in the course of lung abscess. The cough is often paroxysmal, quantities of sputum are brought up, purulent and usually foul. At one time or another the sputum is apt to be blood-tinged or bloody. The cough exhausts the patient, interferes with sleep and not infrequently produces vomiting of a large part of the food taken. The loss of sleep, of nourishment and the sepsis tell heavily on the general condition of the patient. There is usually rapid loss of flesh and strength. Dyspnœa ordinarily is not a conspicuous symptom. When present it may be due to limitation of the respiratory excursion because of pain or bronchial obstruction at the root. (Lord.)

The physical signs are much less reliable than history and symptoms in arriving at a diagnosis. They are in no way pathognomonic of the condition. Dulness on percussion is probably the most constant single sign. Changes in breath sounds are present but vary, depending on the stage of the abscess, its proximity to the chest wall, whether filled or empty, etc. Râles of various kinds, transmission of the whispered voice, etc., may be present. These and other physical signs do no more than denote pathology in a given area, but furnish one more link in the chain of evidence. Tenderness on firm percussion if looked for is found quite often and is of distinct value in localizing proximity to the chest wall. Clubbing of the fingers and watch crystal fingernails develop rapidly in some instances.

Abscess following pneumonia may be very difficult of diagnosis because it is obscured by the already existing pathology. However, if intermittent fever develops with chills and sweats or fever develops after a decline, lung abscess should be thought of and the possibility energetically investigated. The sudden expectoration of a large quantity of purulent material, of course, at once makes evident the rupture of either a pulmonary or extra-pulmonary collection of pus into a bronchus. The aspiration abscess is easier of diagnosis. At first it may be mistaken for a broncho-pneumonia but with the development of a profuse and foul expectoration within two or three weeks following operation there is little doubt as to the condition. The chronic type of abscess of insidious onset and undetermined etiology, especially if it involves the upper lobe, may be confused with tuberculosis. In such a case only the absence of the tubercle bacillus on many sputum examinations would suggest the possibility of chronic abscess.

Bronchiectasis may be a difficult condition to differentiate from chronic abscess. Here, however, the bronchoscopist by direct inspection and by bronchoscopic pneumonography will furnish valuable aid. Abscess, gangrene and bronchiectases sometimes coexist, and it be merely a question of which is the predominant condition. Leukocytosis is almost invariably present in lung abscess. "Elastic tissue with areolar arrangement in the sputum is

certain evidence of a pulmonary destructive lesion and when unaccompanied by tubercule bacilli is strong evidence against pulmonary tuberculosis. Absence of free communication between the abscess and the bronchi is the usual explanation of the difficulty in demonstrating elastic tissue in many cases." (Lord.)

Bronchoscopy furnishes valuable aid not only in the diagnosis of pulmonary suppuration, but also in definitely localizing it. The X-ray is almost indispensable as a means of accurate diagnosis. The most characteristic appearance is a roughly circular shadow of variable size surrounding a central rarefied area. The margins may be moderately well defined or represented by a zone less dense and perhaps mottled, which gradually merges into the normal. Not uncommonly the shadow is cone-shaped with the base at the periphery. One or more cavities may show in the plates, and if partly empty frequently a fluid level can be made out. The X-ray shows well the extent of the inflammatory reaction. Fluoroscopic examination and stereoscopic plates determine the location of the abscess and its relative proximity to the chest wall, a matter of great importance in considering operability. If possible X-ray examinations should be made at several sittings before arriving at a final conclusion and should include lateral views. A negative X-ray plate does not exclude abscess which may be hidden by the heart or diaphragm. In such a case additional information might be obtained by introducing lipiodol through the bronchoscope and reëxamining with the X-ray. Bronchoscopy in conjunction with the X-ray will go far in helping to differentiate lung abscess from other pulmonary conditions. Insufflation of dry bismuth subcarbonate through the bronchoscope by the Jackson method[9] preliminary to X-ray examination outlines the bronchi and demonstrates any bronchiectatic condition that may exist. This pneumonography or "lung mapping" is advisable in most cases of suspected chronic abscess before beginning any kind of treatment.

Treatment.—The treatment of pulmonary abscess demands the close coöperation of the internist, the bronchoscopist, the röntgenologist and the surgeon. The first principle here as in suppuration elsewhere is the establishment of drainage. The problem differs, however, in that the lung is a multilocular structure which communicates with the outside of the body by means of a tube which may be depended upon in a certain number of cases to furnish the necessary means of escape for the products of suppuration. The prospect for cure, then, depends either on the establishment of this natural drainage or of drainage by surgical measures.

Of the various aids to the establishment of drainage which may be employed, posture is the simplest. It is astonishing with what rapidity an abscess which has free communication with a bronchus may become obliterated through this treatment alone. When an expert bronchoscopist is available, bronchoscopic drainage and treatment is used in conjunction with posture. Three or four times a day the patient is placed in the most advantageous

position for the outflow of pus and once a week the bronchoscope is passed and the abscess aspirated. With the bronchoscope in place local treatment can be carried out with various medicaments. Where stricture of the bronchus leading to the abscess exists and drainage is impaired, Jackson and his associates, Tucker, Clerf, Lukens and Moore, do not hesitate to use gentle dilatation. Bronchoscopic treatment in properly selected cases and in the hands

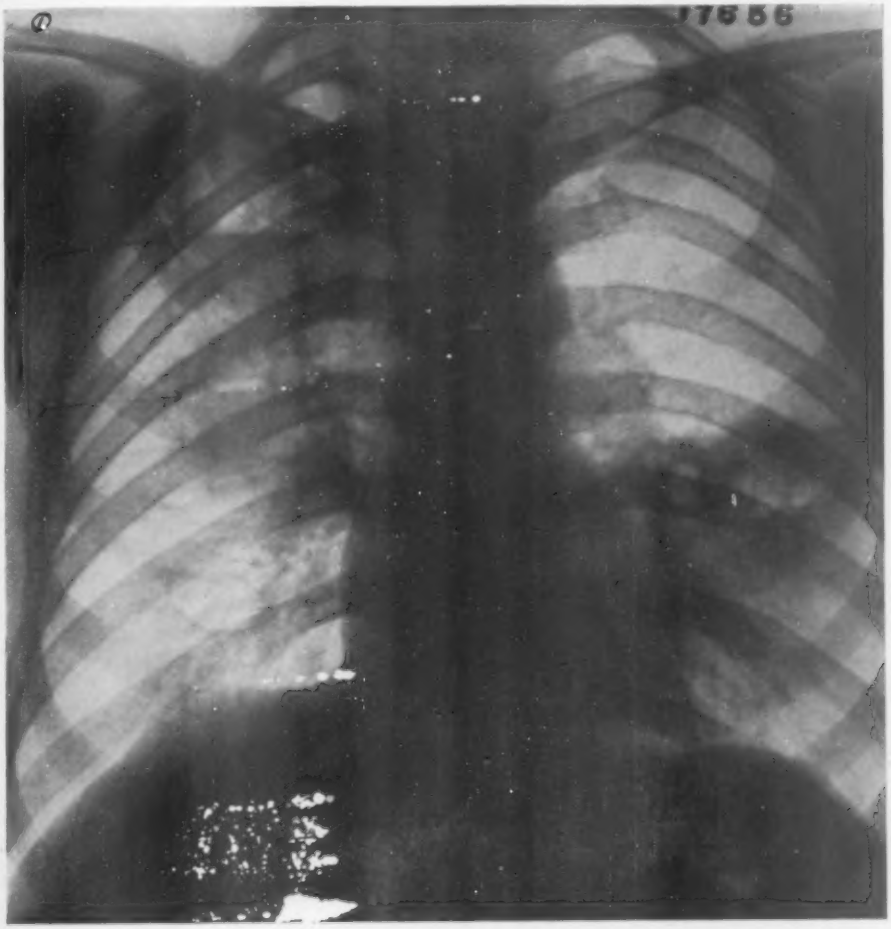

FIG. 1.—Post-tonsillectomy abscess involving the right upper lobe and the base of the left upper lobe.

of an expert is quite free from danger and in many instances will effect a cure. Jackson [10] says it should not be used in the presence of fulminating suppurative pneumonitis or where the abscess has extended to the periphery and there is imminent danger of its rupture into the pleural cavity. He also states that recent severe hemorrhage may be a contra-indication and that it should not be used in organic disease of the cardio-vascular system and hyperextension of high degree. Many cases of lung abscess, particularly the aspiration type, have been cured by the combination of postural drainage and bronchoscopic treatment and many others have been improved so that they

came to operation far better operative risks. Not one of those treated in the Jackson Clinic (Tucker, Clerf, Lukens, Moore) have been made worse, but no case has received bronchoscopic treatment which from the start obviously was in need of external drainage. In one of our recent cases of aspiration type an abscess was present in both upper lobes. (Fig. 1.) The right upper lobe abscess was completely cured by bronchoscopic treatment, but the left

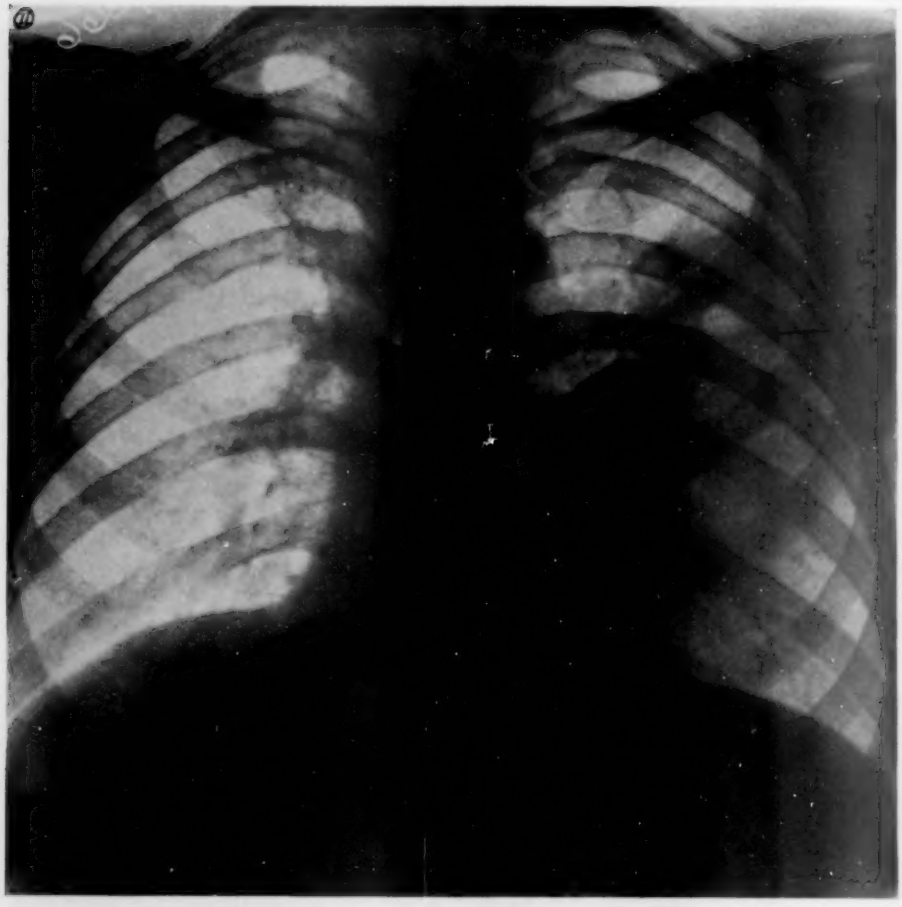

FIG. 2.—The same patient after bronchoscopic treatment by Dr. Louis Clerf of the Jackson Clinic, Jefferson Hospital. The right upper lobe is practically clear.

upper lobe abscess did not improve. (Fig. 2.) This was drained externally and the patient is now well on the way to recovery. (Fig. 3.) A striking feature of the bronchoscopic treatment is the rapidity with which odor will disappear from the sputum and the general improvement in the condition of the patient. In foreign body cases the abscess as a rule will clear up after removal of the foreign body and without further local measures. In cases of other than foreign body origin, the earlier bronchoscopic treatment is instituted the better are the prospects for cure. In long-standing cases of this kind, little more than improvement and amelioration of symptoms can be

expected. Following surgical drainage, after the drainage tubes have been removed and during the period when the external sinus is contracting, bronchoscopic aspiration is a safeguard against the relighting up of the suppurative process.

Centrally located abscesses without pleural involvement may be treated by artificial pneumothorax. Tewksbury [11] reports eleven cures out of four-

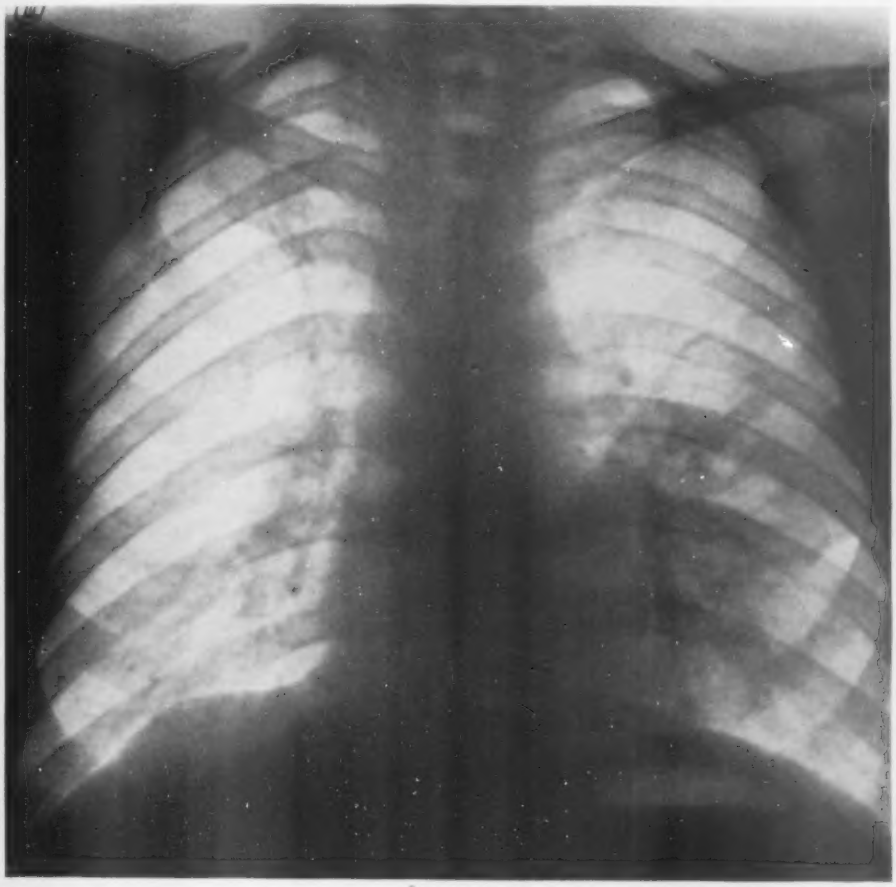

FIG. 3.—Same patient six months after external drainage of the left upper lobe abscess. Practically symptom-free, but with sinus which necessitates small dressing.

teen cases and three deaths. Goldberg and Biesenthal [12] report three cures, and Rich [13] reports six cures and two deaths in eight cases. In addition to the dangers of artificial pneumothorax *per se* there is the added risk of rupturing the abscess into the pleural cavity, a most serious and often fatal complication. Most authorities while admitting that a small percentage of acute abscesses may be cured by this method of treatment do not look upon it with favor. In centrally located abscesses there is no particular reason why a small artificial pneumothorax should not be induced and followed by X-ray examination for the purpose of determining the presence or absence of

adhesions and their location. In the absence of adhesions artificial pneumothorax might be tried, but it is a question whether these cases would not do equally as well if treated by bronchoscopic drainage which carries with it no particular risk.

Regardless of the method employed to establish drainage, the patient should be placed on a strict antituberculous régime, employing every possible means to raise the resistance and improve the general condition. Forced feeding and fresh air are of the utmost importance. In almost every case conservative treatment should be given a fair trial before resorting to operative interference. In a small percentage of cases the abscess is so large and the patient so ill that procrastination would court disaster and external drainage is urgently necessary. Such cases are in constant peril of drowning in their pus.

Operation should be practiced on patients who after thorough trial of conservative treatment are no longer improving or fail to hold their own. The group of cases in which the abscess cavity is surrounded by markedly fibrosed walls will probably almost always come to operation, but often a great deal is gained by treating them conservatively until they have obtained the maximum benefit of such treatment.

Preceding operation the patient is studied under the fluoroscope and stereoscopic X-ray plates made. If possible, exposures are made with the patient in both the horizontal and vertical positions. Lateral plates are of value as they may show an abscess which in other views would be hidden by the diaphragm or the heart. The information thus gained, together with the findings on physical examination enables one to determine at which point the abscess is nearest the chest wall. In several of our cases the point of maximum tenderness on percussion seemed to correspond pretty well with the point selected by the röntgenologist as the best site for drainage.

After the abscess has been localized as accurately as possible the incision is planned, keeping in mind a twofold object, namely, drainage and obliteration of the cavity. In acute or recent cases and in a certain number of chronic cases, obliteration of the cavity will probably take place if adequate drainage is established and continued for a sufficient length of time. The expansion of the lung and contraction of scar tissue making unnecessary any plastic procedure. In the chronic cases of long standing, with perhaps one or more abscesses that do not connect with the main drainage tract, a more formidable procedure must be undertaken.

As a general proposition an upper lobe abscess can best be reached through the anterior or antero-lateral chest wall, although it is sometimes necessary to use a posterior approach. In the latter case, if necessary, the scapula can be winged outward after dividing the rhomboid muscle. Lockwood says that no permanent disability follows "if the muscles themselves are properly sectioned and transplanted or repaired and if fixation is avoided by moving the arm and shoulder from the first." In two of Hedblom's cases in which

the abscess lay posteriorly and high, good exposure was obtained by resecting the angle of the scapula.[14] In lower lobe abscesses the approach of choice is posterior or posterolateral.

If the abscess is situated in the region where the interspaces are wide an intercostal incision suffices for the purpose of exploration. If adhesions are present and the abscess of the acute type, drainage may be instituted at once without resorting to rib resection. However, in the majority of cases the problem is—not so simple and ample room should be provided by subperiosteal resection of three or four inches of two or more ribs. Wounds in the chest wall heal with amazing rapidity and unless the opening is a large one the sinus may become too narrow for adequate drainage before obliteration of the cavity has taken place. In some instances it is well to remove the intercostal structures pealing off the periosteum from the pleura, together with the intercostal muscles, nerves and vessels. A thickened opaque pleura indicates the presence of adhesions, but adhesions may be present in one part of the exposed area and not in another. Very often when adhesions are not present the lung can be seen gliding beneath the pleura and the pleura will look and feel normal. A small incision through the parietal pleura and exploration with the finger is often the safest means of settling the question of adhesions and the exact location of the abscess. If while making the investigation the lung has become retracted by air rushing into the pleural cavity, Graham advises closing the pleura and postponing any further procedure until the lung again fills the pleural space. The site of the abscess will then have been determined and at a second operation adhesions can be produced in the usual manner. A vaselinized gauze plug in the wound makes a good temporary closure of the pleural cavity.

In the majority of cases which come to operation adhesions are present where the abscess is nearest the chest wall, and if this site is the point of approach it is merely a question of determining whether the adhesions are sufficiently dense and extensive to warrant immediate drainage. When in doubt it is better to block off the pleural cavity by surrounding the area to be opened with a chain of catgut sutures which take in the intercostal muscles, the pleura and the lung and pack the wound open with vaselinized gauze. After the lapse of five or six days or longer, adhesions will have formed and the second stage can be undertaken without the risk of infecting the pleural cavity.

After proper exposure of the abscess, if satisfactory adhesions are present or previously have been established, the location of the pus is searched for with an aspirating needle, keeping in mind that in the majority of instances the abscess is near the periphery. If pus is found the lung is opened along the track of the needle, either with a knife or cautery, and the cavity entered. In some cases it is well to enlarge the opening with the cautery, or as Lockwood advocates, take the entire top off with a scalpel. Lockwood does not employ the cautery until the cavity is thoroughly exposed and all débris

has been removed. He says that the cautery gives a false sense of security. He employs hot packs to control the bleeding and after thoroughly cleaning out the abscess ties off the larger vessels, and if necessary, applies a cautery here and there to control oozing. It has been our practice to employ soft rubber tubing to drain the cavity, and if the opening in the lung has been made large with the cautery, the tubing is surrounded with vaselinized gauze so as to fill the wound. The wound in the chest wall is usually left wide open. A good exposure of the abscess cavity permits of subsequent local treatment such as the application of medicaments and the aspiration of the bronchi opening into it, as suggested by Graham. It also gives a sense of security as there is always the possibility of secondary hemorrhage and with a good opening in the abscess cavity, hemorrhage can better be controlled.

Lockwood crushes all bronchi and ties them off with catgut. After the cavity is thoroughly dried he packs it with gauze rung out of glycerine and saline. After four days the pack is removed. At the earliest possible moment Lockwood brings skin flaps in to overlay and close the cavity. Graham [15] has done excellent work in cases of chronic pulmonary suppuration. He uses the cautery freely and does not seem to fear pulmonary hemorrhage. By his method the abscess is entered with the cautery and a large cavity burned out of the lung. If hemorrhage is encountered, it is controlled by packing, which is removed in two or three days' time. At first no attempt is made to burn away a large mass of lung tissue. The idea is rather to establish numerous bronchial fistulæ through which massive drainage may be obtained. At later stages, if necessary, more and more lung can be burned away by increasing the depth of the cavity. The question of how much and how often to cauterize will be determined by the progress of the case after the first cauterization. In some of Graham's cases one cauterization has been sufficient. In others as many as six or eight have been required. He has never found any difficulty in controlling hemorrhage by packing. He warns, however, that it is unwise and dangerous to attempt an extensive cauterization through a small opening or to attempt too much at the first cauterization. Graham's operation of cautery pneumectomy in his hands has given very good results, even in extensive cases of long standing. In thirty-one cases of chronic lung suppuration treated by cautery pneumectomy recently reported by Graham, nineteen per cent. were free from symptoms and completely healed and thirty-six per cent. were free from symptoms but with remaining bronchial fistula. In this series there was a twenty-two per cent. mortality. In a certain number of chronic lung abscesses of long standing a fistula results regardless of the type of operation employed. Some of these fistulæ will close spontaneously after a period of six months or more. Others may persist indefinitely. While such fistulæ can occasionally be closed by plastic procedure, it may be wiser to rest content with the relief of symptoms and the little inconvenience that the fistula brings about. The establishment of adequate drainage is the primary consideration in the treatment of pulmonary abscess,

and while an extensive operation may be necessary in some cases to obtain this result, such are in minority. The more radical surgical procedures should be reserved for long-standing cases of pulmonary suppuration which are not relieved by drainage operations. The acute type of abscesses should be drained for at least five or six weeks. In the chronic type it is necessary to continue drainage for a much longer period of time. Where pyopneumothorax complicates pulmonary abscess, the pulmonary lesion becomes of secondary consideration and prompt drainage of the pleural cavity should be instituted. Such cases are extremely serious and often fatal.

Anæsthesia.—General anæsthesia should never be used in this type of surgery. It is permissable to use gas-oxygen analgesia in conjunction with local or nerve block anæsthesia where it seems necessary to take the edge off the ordeal, but anæsthesia must never be pushed to the point of abolishing the cough reflex. If the patient wishes to cough, the mask is removed and the operation momentarily suspended. Where intercostal thoracotomy is to be employed or one or two ribs resected, infiltration with "field block" is sufficient. In more extensive operations paravertebral anæsthesia with local infiltration anæsthesia is the procedure of choice. Morphine and atropine are given by hypodermic injection a half hour before the time set for operation.

Results of Surgical Treatment.—The operative results are decidedly better in the acute than in the chronic cases of lung abscess and the mortality is lower. The chronic abscess because of associated bronchiectasis and very often multiple small abscesses require more extensive surgical procedures. In some long-standing cases it may be necessary to establish a permanent bronchial fistula. The general mortality varies from fifteen to thirty-five per cent. Hedblom, in 1919, reported the results in thirty cases of acute abscess with 66.6 per cent. cured or improved and 33.3 per cent. dead. Seventeen cases of chronic abscess with 41.1 per cent. cured or improved and 11.7 per cent. not improved and 47 per cent. dead.

It is difficult to sort out results from the literature because many authors group their cases as chronic pulmonary suppuration. Whittemore [16] says "from sixty to seventy per cent. of the cases operated upon may be expected to be cured or permanently improved.

It is quite certain that earlier clinical recognition of the condition with the prompt institution of proper treatment will do much to reduce the mortality and morbidity of lung abscess. It is the long-standing cases that present almost insurmountable obstacles to cure by any form of treatment, but even these can hope for improvement from surgery. Surgery should not be resorted to as soon as the diagnosis of lung abscess is made, except in the few cases which obviously demand surgical drainage. On the other hand, conservative treatment should not be unduly prolonged once it is evident that it is not bringing the desired result. Bronchoscopy is an aid not only in the diagnosis, but in the treatment of lung abscess, but it should be employed only by an expert. In the hands of the inexperienced it is dangerous.

It is fair to assume that more care in the management of patients under general anæsthesia and the more extensive employment of local anæsthesia in operations about the upper respiratory passages will do much to lessen the incidence of at least one type of pulmonary suppuration.

REFERENCES

[1] Fetterolf, Geo., and Fox, Herbert: The Paratonsillar Tissues in Relation to Post-tonsillectomy Abscess. Proc. Am. Laryngol. A., 1923.

[2] Moore, W. F.: Pulmonary Abscess. J. A. M. A., vol. lxxviii, p. 1279, April 29, 1922.

[3] Myerson, M. C.: Pulmonary Aspects of Tonsillectomy Under General Anæsthesia. Laryngoscope, vol. xxxii, pp. 929–942, December, 1922.

[4] Lord, F. T.: Pulmonary Abscess. Boston M. and S. J., vol. cxcii, pp. 785–788, April 23, 1925.

[5] Norris and Landis: Chest Diseases. 3rd Edition, W. B. Saunders Company, Philadelphia.

[6] Wessler, H.: Suppuration and Gangrene of Lung. J. A. M. A., vol. lxxiii, pp. 1918–1921, December 27, 1919.

[7] Lambert, A. V. S., and Miller, J. A.: Abscess of Lung. Archives of Surgery, vol. viii, pp. 446–456, Pt. 2, January, 1924.

[8] Lockwood, Ambrose L.: Surg., Gynec. and Obst., vol. xxxv, pp. 461–492, October, 1922.

[9] Jackson, Chevalier: Bronchial Tree, Its Study by Insufflation of Opaque Substances in the Living. J. Roentgenol., vol. v, p. 454, October, 1918.

[10] Jackson, Chevalier and others: Bronchoscopy as Aid to Thoracic Surgeon. J. A. M. A., vol. lxxxiv, pp. 97–103, January 10, 1925.

[11] Tewksbury, W. D.: Acute Pulmonary Abscess: Report of Fourteen Cases Treated with Artificial Pneumothorax. New York M. J., vol. cx, pp. 849–851, November 22, 1919.

[12] Goldberg, B., and Biesenthal, M.: Treatment of Lung Abscess by Artificial Pneumothorax. Amer. Rev. Tuberc., vol. iii, p. 169, May, 1919.

[13] Rich, H. M.: Acute Lung Abscess. Am. J. M. Sc., vol. clxiv, pp. 428–436, September, 1922.

[14] Hedblom, C. A.: Collected Papers of the Mayo Clinic, vol. xi, 1919, W. B. Saunders and Company.

[15] Graham, E. A.: Rôle of Surgery in Treatment of Pulmonary Suppuration. J. A. M. A., vol. lxxxv, pp. 181–184, July 18, 1925.

[16] Whittemore, W.: Non-tuberculous Pulmonary Abscess. Surg., Gynec. and Obst., vol. xxxviii, pp. 461–465, April, 1924.

AN EXTRAPERITONEAL TRANSDIAPHRAGMATIC ROUTE FOR LOWER INTRATHORACIC SURGERY

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In a preliminary report a brief description was given of a route of approach to the lower thoracic organs without disturbing the rigidity of the chest wall. (Annals of Surgery, December, 1924, vol. lxxx, p. 908.) It was pointed out at that time that an intercostal incision with rib resection was not an ideal procedure because it was instrumental in changing normal

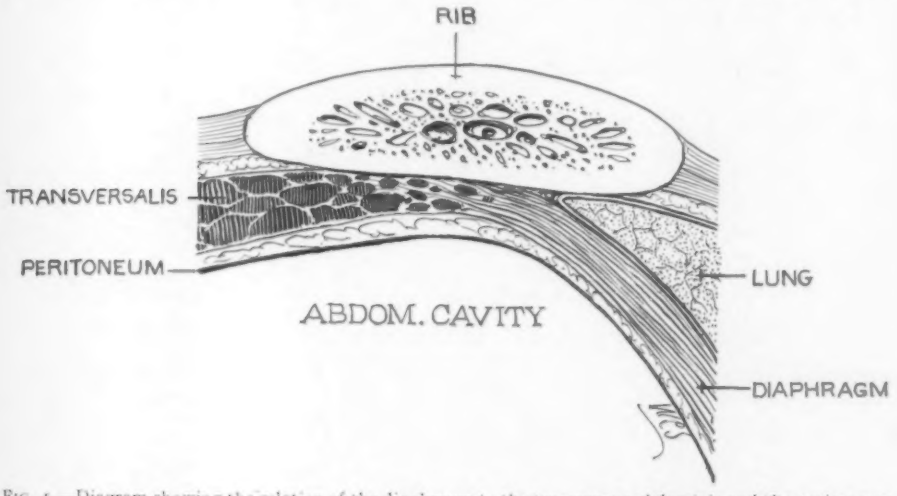

Fig. 1.—Diagram showing the relation of the diaphragm to the transversus abdominis and the peritoneum at the point of subcostal attachment.

intrathoracic pressure variations that are very essential in keeping up certain respiratory and circulatory functions. A defect in the rigidity of the chest wall decreases the vital capacity of the lungs mechanically. Tendency to dyspnœa will be increased with such a deformity in the chest wall. In a previous paper (*Arch. Int. Med.*, January, 1924, vol. xxxiii, pp. 145–154) it was shown that in dyspnœic conditions the ultimate voluntary reserve of increase in the amplitude of respiration becomes diminished in direct proportion to the degree of dyspnœa. The term "ultimate voluntary reserve" is used to signify the difference in the volume of air between the vital capacity and the tidal air in conditions of dyspnœa. If, then, the patient develops heart disease or pneumonia and thus his ultimate voluntary reserve is diminished, he will, undoubtedly, either die or else find himself in extreme difficulties when he has a flabby non-rigid chest wall in addition to his heart

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and lung disturbance. By the use of the route described in this paper the rigidity of the chest wall remains unchanged and an easy access is obtained to the organs in the lower chest.

The peculiar anatomy of the diaphragm and the transversus abdominis muscle makes the procedure a possibility. The diaphragm and the transversus abdominis interdigitate at the point of their attachment. By incising these

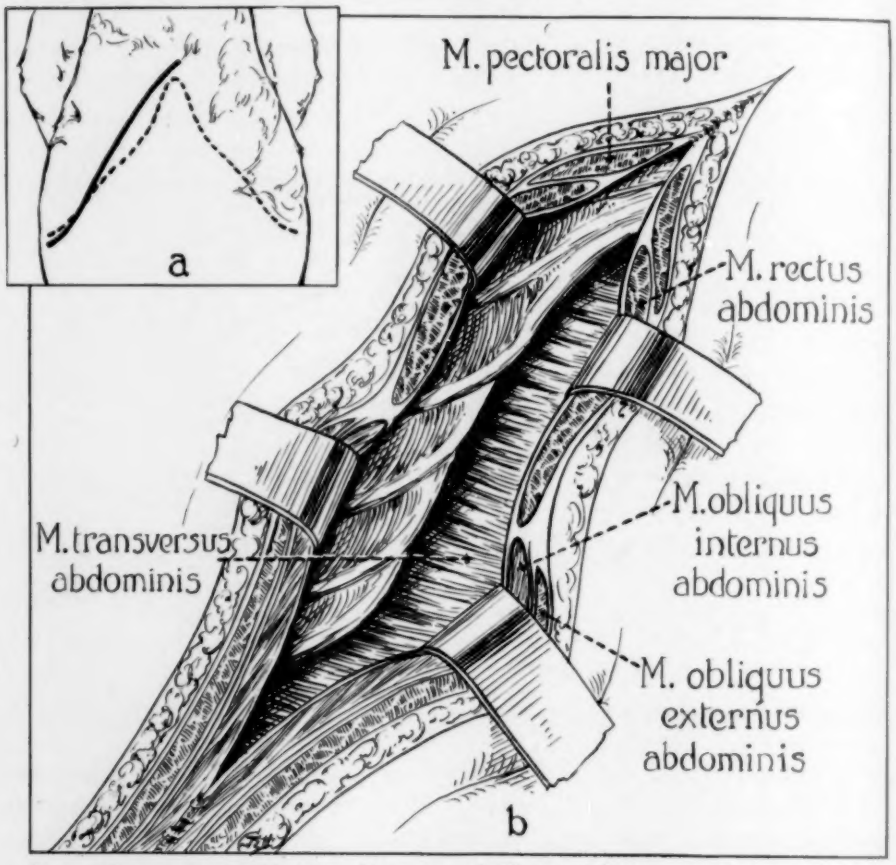

FIG. 2.—Shows a paracostal incision. The rectus and oblique muscles are cut and the costal margin is dissected free. Insert shows line of incision.

muscles at this point one can easily enter the pleural cavity without disturbing the peritoneum or the ribs. (See Fig. 1.) When the muscles are approximated properly there is no fear of post-operative hernia or, in the presence of an infection, of danger of peritoneal infection. Judging from the results of 48 such experiments on the dog, we may discard these objections as having little or no foundation if the intercostal nerves and the peritoneum are not disturbed. An advantage in this procedure is that after operation the diaphragm becomes temporarily immobilized and thus minimizes the possibility of infection originating in the lungs.

The Operation.—In the preliminary report a high rectus incision was

advised. In the course of our later experiments it was noticed that a paracostal incision, either above or below the costal margin, is to be preferred. By this means a better exposure can be assured. Care should be taken not to cut the thoracic nerves when the incisions are made. After the oblique muscles are cut and in some cases some fibres of the latissimus dorsi and the serratus anterior, the costal margin is dissected free by means of blunt dissection. (See Fig. 2.) The dissection is done subcostally until the point of attachment of the diaphragm and the transversus abdominis is reached. By lifting the ribs up at the costal margin and exerting a slight pressure on the abdominal wall, the point of attachment of the diaphragm and transversus comes into view more easily. Blunt dissection insures against the danger of injuring the peritoneum. (See Fig. 3.) If the peritoneum is accidentally cut, it should be sutured before the chest is opened and thus no danger of a postoperative hernia enters into the procedure. (See Fig. 4.)

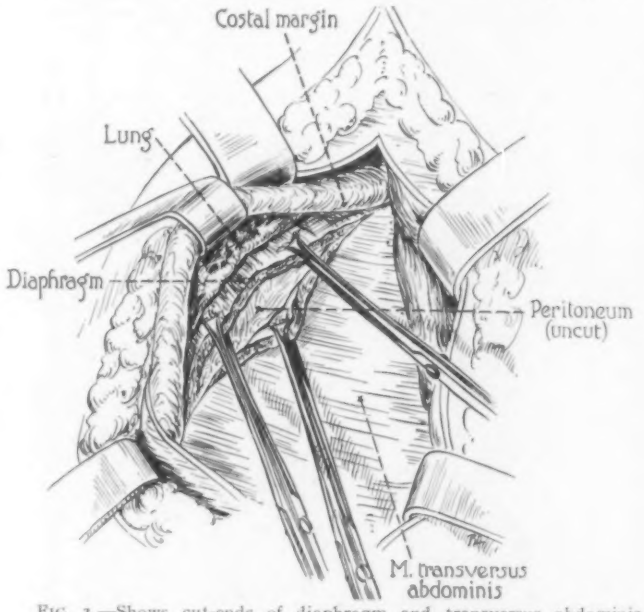

FIG. 3.—Shows cut-ends of diaphragm and transversus abdominis muscles with uncut peritoneum coming into view. By lifting on the costal margin, tip of lower lobe of lung comes into view.

Just before incising the diaphragm artificial respiration is started and is continued until the chest is completely closed. If at any time the artificial respiration is not satisfactory, the opening of the diaphragm can be closed by inserting the fingers or, in some cases, the whole hand, into the opening. The opening in the diaphragm is now enlarged by cutting as close to the chest wall as possible. The incision may be extended as far as the midline anteriorly and as far as the posterior axillary line laterally. By pulling up on the ribs and pushing down on the diaphragm a large enough opening can be produced to work as high as the hilus of the dog's lung. The diaphragm can be best retracted by using a wide spoon-like retractor. Under the ribs at the point of incision of the diaphragm one may encounter bleeding. This can be easily controlled by applying pressure with gauze by means of the rib retractor. Thus one can get both retraction and hæmostasis.

Before doing any intrathoracic work it is necessary to suture together the cut edges of the diaphragm and the transversus abdominis with interrupted

sutures. The ends of these sutures should be left long and needles be threaded to these ends, so that the wound can be closed promptly if any necessity arises. (See Fig. 4.) When one is ready to close the chest, he can take the interrupted sutures and transfix them to the chest wall by passing the sutures and tying them to the intercostal muscles. When all the sutures are applied the chest again becomes air-tight. In the presence of a leak one becomes aware of a wheeze with each inspiration. This sound is an indication of more suturing until the sound disappears. The costal margin is now sutured to the abdominal wall. Care must be taken during this step not to injure intraperitoneal organs. The muscles are then approximated and the skin is sutured in the usual fashion. If no work is done on the lungs, it is found advisable to aspirate the air from the chest. The contrary was found more desirable when lung surgery was done.

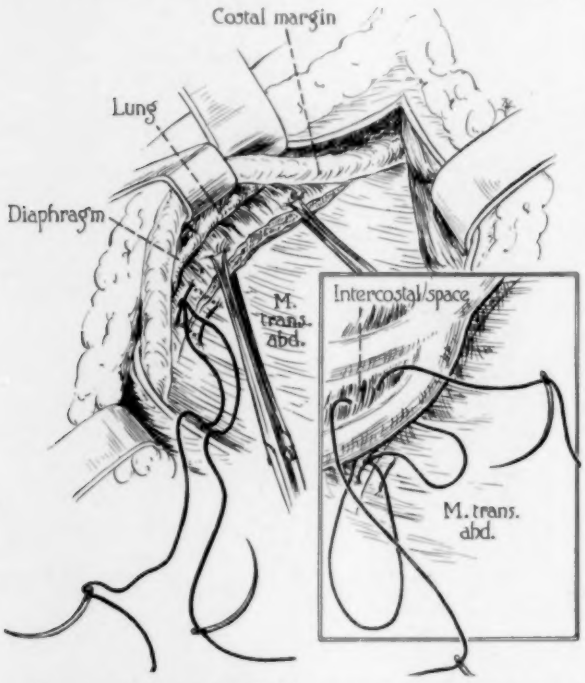

FIG. 4.—Diaphragm is pulled by means of clamps and is sutured to transversus abdominis muscle. Pleural cavity open with tip of lung showing. Insert shows suturing of abdominal muscles to chest wall.

For the artificial respiration two methods were employed. A Gessel-Erlanger (*Amer. Jour. Physiol.*, 1914, vol. xxxiii, p. xxxiii) artificial respiration tank was used in the earlier experiments. This tank is very satisfactory because it affords an intermittent positive pressure, the rate of the blasts being regulated by the amount of air that passes through the tank. The pressure of the air remains the same. Some of the experiments were performed with an ordinary foot pump. Under such circumstances a pharyngeal tube was inserted into the mouth of the dog and an intermittent pressure was exerted on the floor of the mouth by pressing the fingers against the muscles of the floor. This manœuvre prevents the escape of air from the mouth and thus is directed into the lungs and expands them. This method is especially desirable when work is done in places where there are no facilities for the production of compressed air.

Results.—Forty-eight such experiments were performed. Of these four experiments were unsuccessful because of poor artificial respiration. These animals died on the table. One animal died three hours after the

operation. In this animal the lower lobe of the lung was removed. An accidental tear on the upper lobe was left unrepaired, with the result that the animal bled to death. Two other animals on whom lobectomy was also performed died 48 hours after the operation. The exact mechanism that caused death in these animals is being studied at present. In these animals the chest was filled with a non-coagulable bloody fluid on the operated side and a clear serous fluid on the normal side. We did twelve lobectomies by

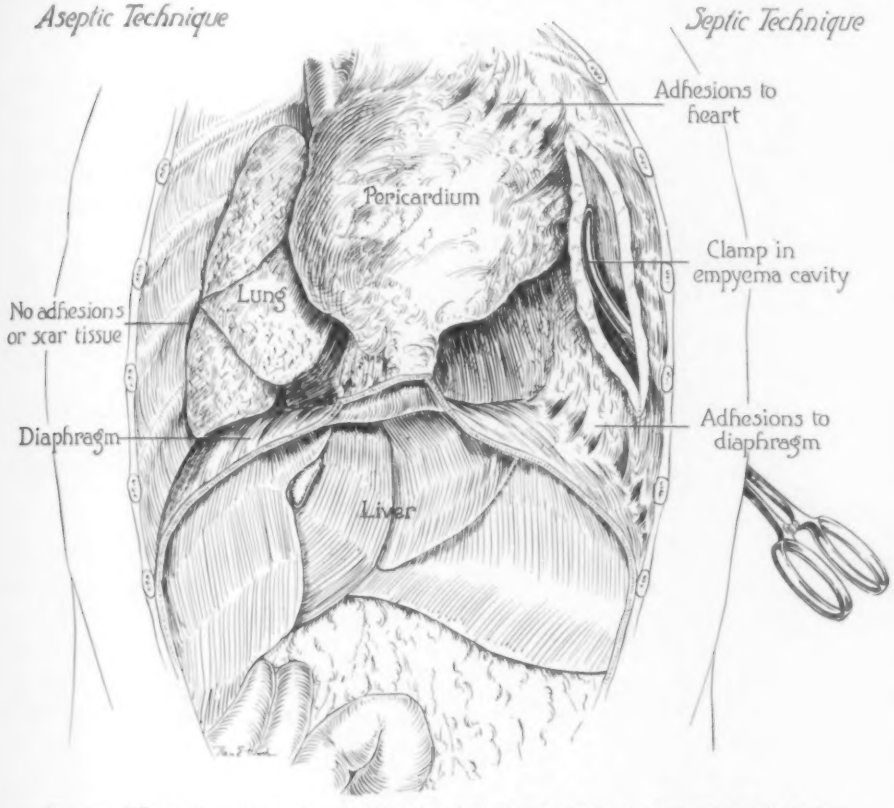

FIG. 5.—Effects of septic and aseptic operations into the pleural cavity through the diaphragm.

using this route. Ten operations were performed on the heart muscle. The heart is very accessible by this method. The longest an animal was allowed to live was 487 days. It was killed at that time and the diaphragm showed a few adhesions at the costo-phrenic angle but perfect healing otherwise. The effect of sepsis on the diaphragm was studied. In the animals in which an abscess was formed as a result of septic technic the abscess was well walled off and the diaphragm held well. (See Fig. 5.) In one animal an abscess occurred in the tissues underneath the oblique muscles. In this case the peritoneum was in no way abnormal and the diaphragm wound gave way only at one point. No pneumothorax developed as a result of this pathologic picture.

In no animal in which a proper closure was performed did we see a

diaphragmatic hernia. This was too good to be true, therefore, an intentional wound of the diaphragm into the peritoneal sac was made. In this animal we noticed a gradual ematiation until the animal looked very much like a living skeleton. When the animal was killed, we noticed that all the loops of the small intestine, part of the cardiac end of the stomach, and the spleen found their way into the chest cavity and filled it up to the level of the second rib. The wound made at the usual point healed and left only a small scar.

CONCLUSIONS

1. The transdiaphragmatic *extraperitoneal* route for surgery of the lower intrathoracic organs is a very desirable procedure in chest operations where one does not want to disturb the chest wall.

2. The distinct advantage of this procedure is the maintenance of an intact chest wall and thus no embarrassment of respiration follows intrathoracic operations.

3. Healing per primam occurs in the cut end of the diaphragm when the operation is done under aseptic conditions.

4. Empyema of the chest occurred in the experiments in which a septic technic was used.

5. A fair access can be obtained to the lower thoracic organs by means of this incision.

6. We hope that eventually this route will find its place in human chest surgery.

SOME NEW PHASES OF THE PHYSIOLOGY OF THE BILIARY TRACT*†

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and

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The gall-bladder is known to have two functions, of which one is concerned with the regulation of pressure within the biliary tract and the other is concerned with the concentration of bile by the absorption of water. Possibly one other function is suggested by the fact that the blood from the gall-bladder empties into the portal vein. It might be inferred from this fact that perhaps something is formed in the gall-bladder which is necessary for the liver to use. At the present time nothing is known about this possible additional function, although Sweet [1] has produced evidence which suggests that the gall-bladder forms something which acts to de-esterize cholesterol esters.

Curiously enough even the question of how the gall-bladder empties itself has aroused interest only within recent years. In 1917, Meltzer [2] proposed his now famous hypothesis of the existence of a contrary innervation between the sphincter of Oddi and the gall-bladder, whereby a dilatation of the sphincter was supposed to be accompanied by an active contraction of the gall-bladder. It is upon this hypothesis that Lyon devised his method of draining the gall-bladder by means of the instillation of magnesium sulphate into the duodenum. Sweet was perhaps the first one to raise serious questions against the validity of the hypothesis. He called attention to the anatomical difficulties which might act as obstacles against the emptying of the gall-bladder through the cystic duct, such as the acute angle which the cystic duct usually makes with the common duct, the presence of the Heisterian valves, etc. There is now, however, a large amount of evidence which seems to prove beyond any doubt that bile passes out from the gall-bladder through the cystic duct. A crucial experiment which shows that the gall-bladder empties through the cystic duct instead of by absorption of all of its contents has been performed by Copher, who showed that if tetraiodophenolphthalein is injected into a dog after the ligation of the common duct, the shadow of the gall-bladder will remain indefinitely, for three weeks, for example, in one experiment, after which the animal was killed.

Of equal interest with this question has been the one of how the gall-bladder empties itself. It is a curious fact that in spite of the countless abdominal operations which have been performed, only one surgeon has

* Read before the American Surgical Association, May 26, 1926.

† This work was aided by a grant from Edward Mallinckrodt, Jr.

reported ever having seen the gall-bladder contract. Matsuo,[3] a Japanese surgeon, states that once he saw it contract after magnesium sulphate had been instilled into the duodenum during the course of a laparotomy. If the gall-bladder contracts in a manner analogous to that of the urinary bladder or the intestine, then one would suppose that by means of cholecystography it would be easy to demonstrate the contraction waves. As a matter of fact, however, not only my associates and I, but also many others have patiently watched the visualized gall-bladder through the fluoroscope but have never seen any suggestion of a contraction wave. Similarly, also, stimuli which cause violent contractions of other hollow viscera in the abdomen elicit no demonstrable response when applied to the gall-bladder. This organ can be pinched with a clamp, incised with a knife or touched with a cautery without the least sign of a contraction wave of any kind. Moreover, as Boyden[4] and Whitaker first showed, an electrical stimulation which will throw the intestine into violent peristaltic contractions will, when applied to the gall-bladder, evoke no response. We have also repeated this experiment many times with similar results. It seems certain from all this, therefore, that if any muscular contractions occur in the gall-bladder they are extremely difficult to demonstrate, and the inference may also be drawn that they are therefore of little importance. The rhythmic contractions of the gall-bladder described by Bainbridge and Dale[5] and by others, are probably nothing more than the effect of pressure exerted by neighboring organs as the result of respiratory movements; at least in the experiments of these authors the possibility of the effect of respiratory movements as a cause of the contractions has not been satisfactorily excluded. Moreover, when the gall-bladder

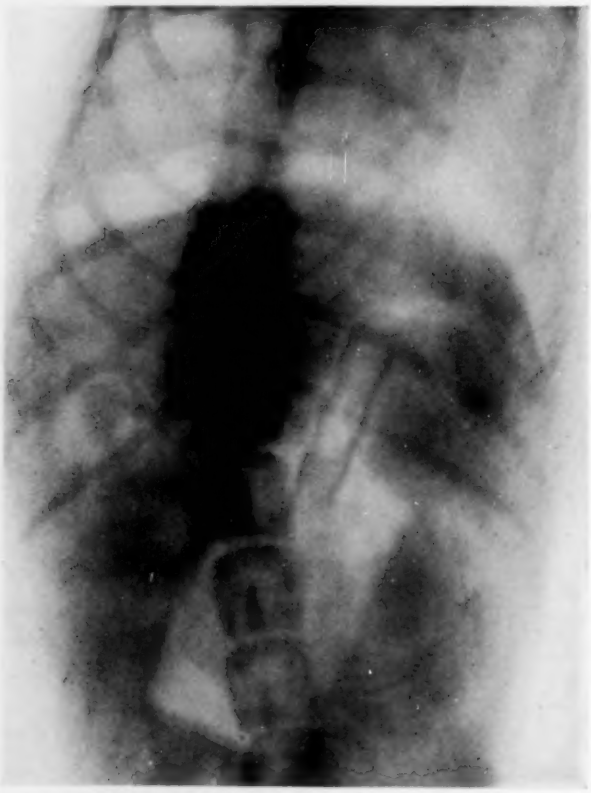

FIG. 1.—Artificial gall-bladder produced by uniting a small rubber bag to the cystic duct of a dog by means of a glass cannula after the normal gall-bladder had been removed. A celloidin cylinder was then placed around the gall-bladder to protect it from changes of intra-abdominal pressure. Twenty-four hours after an intravenous injection of tetraiodophenolphthalein the gall-bladder is just faintly visible.

itself is examined, it is found that its muscle tissue is relatively scanty. Boyden states, "the muscularis of the intestine is considerably thicker than that of the gall-bladder, the difference being far greater than appears, since the fibres in the intestine are so much more closely packed" but "the connective-tissue layer of the gall-bladder is nearly three times as thick as that of the intestine and, as stained with resorcin fuchsin, is evidently much richer in elastic tissue; this tissue is surely an important factor in the mechanics of the gall-bladder."

Copher and Kodama, in our laboratory, have recently performed crucial experiments, not yet published, which can leave little doubt that whatever active muscular contraction there may be, it can at most play only a minor rôle in the emptying of the gall-bladder. The chief factors in its emptying are purely passive and are explained on simple mechanical principles as follows: The gall-bladder is a distensible viscus which responds to increased pressures in the common duct by becoming distended. When the ductal pressure is suddenly lowered by a sudden opening of the intestinal end of the duct, there is an elastic recoil on the part of the wall of the gall-bladder which results in the ejection of bile from the organ. Also, as the bile is streaming down the common duct past the orifice of the cystic duct there may be some siphonage action in a manner analogous to that of the filter pump well known to chemists, although the Heisterian valves may interfere somewhat with the exit of bile in this way. The intermittent sudden opening and sudden closing of the duodenal end of the common duct results, therefore, in a gradual washing out of the gall-bladder. But obviously it can never be entirely empty. Copher has shown that if daily injections of tetraiodophenolphthalein be given to a dog a shadow of the gall-bladder remains throughout the entire period of the experiment. This shows conclusively that the gall-bladder is never empty, at least during the period of the experiment. The intermittent opening and closing of the duodenal end of the common duct is in turn dependent chiefly upon the state of contraction of the wall of the duodenum. Kodama has devised a model to illustrate the filling and emptying of the gall-bladder based on these principles, and a description of it will appear in the June number of the *American Journal of Physiology*.

If now these conceptions are correct, then it should be possible to substitute in a living animal an artificial elastic gall-bladder which would act very much like a normal one in emptying and filling. Such was found to be the case.‡ Copher and Kodama removed the gall-bladder from a normal dog and connected a small rubber bag with the cystic duct, at the same time surrounding the artificial gall-bladder with a celloidin cylinder to prevent pressure on it from other organs. By using cholecystographic examinations with the aid of tetraiodophenolphthalein it was found that this rubber gall-bladder behaved like a normal one, except that of course there was no ability to concentrate the bile by absorption of water and that a slightly longer time

‡ The details of this work will appear in a forthcoming issue of the Jour. of Exper. Medicine.

was required for emptying, due probably to the facts that the elasticity of the rubber bag was not quite the same as that of the normal gall-bladder and that also the factor of intra-abdominal pressure was excluded by the use of the celloidin protector.

There is also much reason to doubt the existence of a true sphincter of Oddi at the end of the common duct in the sense usually understood. At least it is not necessary to assume that any such sphincter plays a major rôle in controlling the outflow of bile from the common duct. Copher and Kodama have found that a distinct sphincter cannot always be found apart from the fibres of the muscle coat of the intestine. They considered that instead the normal tonus of the duodenal wall might be an important factor in the resistance to the flow of bile into the duodenum because they observed discharges of bile from the duodenal papilla coincidently with duodenal peristaltic movements. While they were experimenting further with this point, Burget [6] published his excellent paper containing his conclusions that undue importance has been attached to the sphincter of the common duct, that resistance to pressure in the common duct is offered by the normal tonus of the duodenum and that peristalsis of the duodenum is an important factor in emptying the duct by a milking action and by aspiration due to reduced pressure following a peristaltic wave. Carlson [7] had also expressed the opinion that the tonus of the duodenal wall is more important than the so-called sphincter of Oddi. It is well known that the common duct passes obliquely through the wall of the duodenum. According to Quain,[8] in the human, it runs obliquely in the wall for a distance of two or three cm. Practically the same anatomical relationship exists in the dog. Copher and Kodama,¶ in work not yet published, have shown that this arrangement constitutes a

FIG. 2.—At the end of forty-eight hours it is plainly visible.

¶ This work will appear in a forthcoming issue of the Archives of Internal Medicine.

sphincter-like mechanism which is dependent upon the tonicity of the intestine and makes it possible for intestinal peristalsis to be a factor in regulating the flow of bile from the common duct. They found that the discharge from the common bile duct into the duodenum occurs during the relaxation phase of a duodenal peristaltic movement, regardless of whether the duodenal peristalsis is spontaneous or induced by chemical, thermal, mechanical or electrical stimuli. During a period of contraction of the duodenal wall it would seem to be impossible for the duct to discharge its contents. Several different substances accredited with the ability to make the gall-bladder discharge its contents were tested from this point of view, and the observations warrant the conclusion that any ability of these substances to cause an outpouring of bile into the duodenum rests chiefly upon their power to induce peristalsis in the intestine with the resulting milking action of the duct from alternate contraction and relaxation. It is therefore unnecessary to assume the existence of the hypothetical contrary innervation of Meltzer or even of the so-called sphincter of Oddi. It is interesting also that magnesium sulphate is much less potent in causing a discharge from the gall-bladder than other substances. Boyden and also Sosman, Whitaker and Edson[9] have shown that a fat meal, especially one containing egg yolk and cream, has the power of reducing the cholecystographic shadow of the gall-bladder to about one-tenth of its former size within the brief time of one hour and forty-five minutes, much more quickly and effectively than magnesium sulphate. Copher and Kodama have found that oleic acid when placed in the duodenum is even more potent in this respect. Pituitrin causes an outpouring of bile, probably chiefly if not entirely, because of its production of peristalsis in the duodenum, and not because of any direct effect on the gall-bladder itself. Incidentally also the relaxation of intestinal tonus was found to be an equally important factor in the emptying of the pancreatic duct.

In this brief summary of some of the newer knowledge of the physiology of the gall-bladder, it has been seen that cholecystography has been of definite help in contributing some of these new facts. With your indulgence I propose now to review briefly some of the features of cholecystography as a method of diagnosis. It will be recalled that the principles upon which the procedure is based are as follows: An opaque substance is secreted by the liver into the bile, passes into the gall-bladder and becomes concentrated there. A failure to obtain a shadow of the gall-bladder may occur under any of the following conditions: (1) Insufficient amount of the substance reaching the liver, (2) inability of the liver to secrete a sufficient amount, (3) blocking of the cystic duct, (4) failure of the gall-bladder to concentrate the material sufficiently, which may be due either to disease of its wall or to too rapid emptying of the gall-bladder from duodenal peristalsis. The factor of failure of the liver to secrete the dye can be neglected because experience has shown that even in the presence of extensive liver damage excellent cholecystograms can be obtained if the gall-bladder is normal. Pribram, Grunenberg and

Strauss [10] have had good visualization of the gall-bladder in cases of clinically diagnosed acute yellow atrophy. More recently Fried and Whitaker [11] have found experimentally that moderately extensive chloroform necrosis of the liver does not prevent good visualization. If the dye has been introduced intravenously, and if care has been taken to exclude peristalsis of the duodenum by withholding food during the period of concentration of bile, a failure to obtain a shadow may therefore be taken as a nearly absolute indication that the gall-bladder is either not concentrating its contents or that the cystic duct is blocked. In our experience it has more often signified the former condition. It is therefore a definite index of function. It has often astonished us to see how slight a degree of gross pathological change is associated with a failure of visualization. We feel therefore that cholecystography is a fairly accurate index of function of concentration. Likewise, since changes in size of the gall-bladder can be observed, we feel that cholecystography is also an indication of the function of regulation of pressure within the biliary system. It will be recalled that these are the only known functions of the gall-bladder. Cholecystography would therefore seem to give us a fairly accurate index of the state of the only functions of the gall-bladder which are known.

FIG. 3.—At the end of ninety-six hours it is less plainly visible than before.

Recently criticisms have been raised against the diagnostic value of cholecystography on the ground that sometimes a normal series of shadows is obtained when at subsequent operation pathological changes are found in the gall-bladder. Richter,[12] in a recent article, calls attention to the recurrence of attacks of gall-bladder disease and states that probably in the intervals and in the early stages of disease the cholecystographic examination would show a normal gall-bladder and hence would be misleading. It is possible that this fear may be correct, but, so far as I know, there is no data to support it. Our own experience is all opposed to this possibility. It is unfortunate that

Richter, like so many others, regards "thick tar-like bile" in the gall-bladder as pathological. On the contrary, such bile is a normal finding and it is a clear indication of the fact that the concentrating function of the gall-bladder is not impaired. It is our belief also that cholecystography, when properly performed, will give evidence of disease before it is recognizable by any method short of microscopic examination of the gall-bladder. This has been our experience repeatedly.

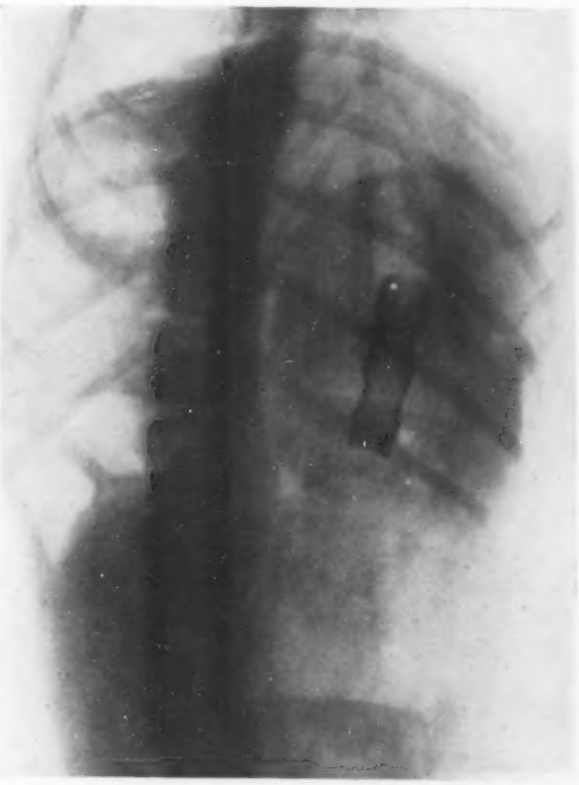

FIG. 4.—At the end of 120 hours the shadow of the gall-bladder has practically disappeared. This experiment shows plainly that it is possible for the gall-bladder to fill and empty itself without the aid of either changes in intra-abdominal pressure or muscular contraction. In this experiment the process of emptying was probably almost entirely due to the washing out of the gall-bladder by a gradual inflow and outflow of bile from the liver. If the factor of changes of intra-abdominal pressure had been present the gall-bladder would have emptied sooner. For further discussion of this experiment, see the text.

Questions such as these bring up for consideration the more important question of what criteria shall be taken for determining abnormality. Is an organ that is functioning normally to be considered as essentially normal in spite of old evidence of disease? Or are we to conclude that even old pathological lesions, as for example adhesions, are to be taken as evidence of active disease demanding treatment? In most of the other parts of the body we are accustomed to a physiological viewpoint. In the case of an old fracture we disregard anatomical abnormality if the function is good; also we do not consider a finger diseased simply because it may present an old scar as evidence of a previous infection. It is possible, therefore, that a functional test of the gall-bladder, such as is made possible by cholecystography, will really prove to be a more accurate index of the actual condition of the organ than gross pathological anatomical findings at operation. If this should prove to be the case, cholecystectomy might become less frequent. As judged by our own experience this would seem to be the case, but I do not think that the method has as yet been sufficiently tested by time to warrant too sweeping conclusions on this point. It would seem safer also to consider calculi in the gall-bladder as potential sources of danger despite the fact that the organ

may appear at the time to be functioning normally. It has been our own and others' experience that occasionally a gall-bladder seems to possess nearly normal functions by cholecystographic examination in spite of a clear revelation of calculi. This, however, is an exceptional occurrence. Finally also in this connection I think it should be stated that, at least in the light of our own experience, the utmost caution should be exercised in drawing conclusions of abnormality from results obtained with the oral administration of any of the substances because of uncertainty of the amount absorbed. We have found that the intravenous method of administration of sodium tetraiodophenolphthalein in our last 150 cases has given 97 per cent. correct diagnoses as compared with only about 75 per cent. with the oral method. All of the removed gall-bladders have been subjected to microscopic examination.

The intravenous method has seemed objectionable to many because of the fear of toxic reactions. The toxicity of the halogenated phenolphthaleins is due largely to the phenolphthalein part of the molecule, rather than to the contained halogen. A substance, therefore, which would give equally good shadows in smaller doses might be expected to be followed by fewer toxic reactions. We have found that the isomeric compound of tetraiodophenolphthalein, namely phenoltetraiodophthalein, gives equally good shadows in doses only about two-thirds as large as those necessary when the tetraiodophenolphthalein is used. Moreover, in a series of 103 patients injected with this substance there have been no severe reactions at all. This substance differs from tetraiodophenolphthalein in that the iodine atoms are on the phthalein part of the molecule instead of on the phenol rings. It possesses also the additional advantage of coloring the serum sufficiently to make it of use as a test of hepatic function in a manner similar to the Rosenthal test.

SUMMARY

1. The hypothesis of Meltzer of the existence of a contrary innervation between the gall-bladder and the so-called sphincter of Oddi has little evidence to support it.

2. The opening and closing of the duodenal end of the common duct depend almost entirely upon tonus of the duodenum, and it is not necessary to assume a separate sphincter to control this mechanism.

3. The spurting of bile through the ampulla of Vater is due largely to the milking action of duodenal peristaltic waves upon the common duct which passes obliquely through the duodenal wall.

4. The emptying of the gall-bladder is chiefly a passive phenomenon due to factors such as the elastic recoil of a distensible viscus and the gradual washing out of its contents by the ingress of fresh bile from the liver. Increased intra-abdominal pressure is also a factor of some importance.

5. The gall-bladder fails to contract when any of the experimental methods are tried which are known to induce violent contraction of either the urinary bladder or the intestine. Muscular contraction of its wall must therefore play an insignificant rôle in the emptying of the gall-bladder.

6. Those substances which are known to induce emptying of the gall-bladder probably have this property by virtue of their ability to cause duodenal peristalsis. Oleic acid seems to be the most potent in this respect.

7. Cholecystography is a test of the only functions known to be possessed by the gall-bladder. If the organ has been shown to be functioning normally, it almost certainly is not causing symptoms, even if at operation old evidence of disease is found, such as adhesions and scarring. Accuracy in interpretating normality, however, demands great care and experience in performing the test. The intravenous method of administration gives much more accurate results than the oral.

8. Phenoltetraiodophthalein possesses many advantages over tetraiodophenolphthalein, and in our own work we are now using it exclusively.

REFERENCES

[1] Sweet, J. E.: The Gall-bladder: Its Past, Present and Future. Int. Clin., 1924, vol. i, p. 187.

[2] Meltzer, S. J.: The Disturbance of the Law of Contrary Innervation as a Pathogenetic Factor in the Diseases of the Bile Ducts and the Gall-bladder. Am. Jour. Med. Sci., 1917, vol. cliii, p. 469.

[3] Matsuo, I.: Magnesium Sulphate as a Cause of the Evacuation of the Gall-bladder. Jour. A. M. A., 1924, vol. lxxxiii, p. 1289.

[4] Boyden, E. A.: The Effect of Natural Foods on the Distention of the Gall-bladder, with a Note on the Change in Pattern of the Mucosa as it Passes from Distention to Collapse. Anat. Rec., 1925, vol. xxx, p. 333.

[5] Bainbridge, F. A., and Dale, H. H.: The Contractile Mechanism of the Gall-bladder and its Extrinsic Nervous Control. J. Physiol., 1905, vol. xxxiii, p. 138.

[6] Burget, G. E.: The Regulation of the Flow of Bile. Am. Jour. of Physiol., 1925, vol. lxxiv, p. 583.

[7] Carlson, A. J.: Physiology of the Liver: Present Status of Our Knowledge. Jour. A. M. A., 1925, vol. lxxxv, p. 1468.

[8] Quain's Anatomy, vol. iii, Part 4, pp. 128 and 141. Longmans, Green and Co., 10th edit.

[9] Sosman, M. C., Whitaker, L. R., and Edson, P. J.: Clinical and Experimental Cholecystography. Am. Jour. Röntgenol., 1925, vol. xiv, p. 495.

[10] Pribram, B. O., Grunenberg, K., and Strauss, O.: Die rœntgenologische Darstellung der Gallenblase und ihre klinische-practische Bedeutung. Deutsch. med. Wchnschr., 1925, vol. li, p. 1429.

[11] Fried, B. M., and Whitaker, L. R.: The Effect of Liver Damage on Cholecystography in Dogs by the Use of Sodium Tetraiodophenolphthalein. Arch. Int. Med., 1926, vol. xxxvii, p. 388.

[12] Richter, H. M.: Cholecystography. Jour. A. M. A., 1926, vol. lxxxvi (March 27), p. 937.

SURGICAL ASPECTS OF CERTAIN PHASES OF LIVER FUNCTION

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The work of numerous investigators focussed on the liver and biliary system under normal and abnormal conditions has led to important recent advances. While our understanding of the physiology and pathology involved, our accuracy in diagnosis and effectiveness in treatment have been greatly increased as a result of these labors, the mass of new material is so great that in certain instances it is difficult as yet to choose measures of actual value in clinical surgery.

The diagnosis of disease principally confined to the gall-bladder through clinical evidence and Röntgen-ray studies, according to the method of Graham and Cole,[1] now compares favorably with that of any other intra-abdominal pathological condition. The same can not be said of surgical disease involving the liver. In fact, the more the liver is affected in surgical conditions, either directly or through disease of the gall-bladder and ducts, the less are available methods likely to give us a complete picture of the situation. Some method for the prompt separation of those cases of jaundice due to surgical conditions, some way of estimating the extent of liver damage in a given case, and in particular, some measure of the adequacy of the liver for the biological needs of the individual are obviously greatly to be desired.

The physiology of the liver and its disturbance in disease therefore have a definite bearing in surgery. The difficulty is to apply what is known of the function of the liver to the study of clinical cases. In spite of the vital importance of the liver and the multiplicity of functions assigned to it, in carbohydrate and protein metabolism, in the storage and modification of fat, in the formation of fibrinogen, in detoxication, and in the excretion of bile pigments and bile salts, its reserve and its power of regeneration are so great that in man, even up to the time of death, there are few changes constantly present which we can attribute to failure of the hepatic epithelium.

Although Mann and McGath [2] have shown a progressive decrease in blood sugar following removal of the liver in dogs leading to characteristic symptoms and death, in man a low blood sugar during the course of hepatic disease is exceptional. Bollman, Mann and McGath [3, 4] have shown in similar experiments that a profound modification of protein metabolism occurs. There is a cessation of urea production, with consequent fall of blood urea if the kidneys are intact. Uric acid accumulates in the blood, in spite of greatly increased excretion in the urine. It seems fair to assume that the liver is equally important in protein metabolism in man. Yet in disease while findings of physiological significance may occur in acute yellow atrophy,

changes in the nitrogenous excretion in the urine, or in the blood chemistry, sufficiently characteristic of liver damage to be of value in routine diagnosis or prognosis rarely occur. In fact, blood chemistry is of greater value in hepatic disease through showing the effects of nephritis or of secondary changes in metabolism than it is with reference to the liver itself.

The obscurity of changes directly dependent upon damage to the liver cells makes clinical tests of function particularly desirable. Although numerous tests have been devised, in their present stages, they are chiefly applicable in the intensive study of groups of cases; few have established themselves as valuable in the clinical routine. Greene, Snell and Walters [5] give a critical consideration of the more promising of such tests. In actual practice the most helpful evidence comes from disturbance of one function, that of bile pigment metabolism. While much valuable information may be gained by a study of the character and amount of bile secretion into the intestine, I wish to refer particularly to the retention of bile pigment in the organism. To discuss this further requires a more detailed consideration of the source of bile pigment, and the relation of the liver to bile pigment formation and excretion. Since the dye tests of liver function bear some relation to the excretion of the normal biliary pigments, it is logical to postpone reference to them until later.

The rôle of the liver in the occurrence of jaundice has been the subject of much dispute, and appears only recently to have been settled. Jaundice may be defined as the abnormal retention of bile pigment within the body. The only known source of bile pigment is hæmoglobin (Rich).[6] Conversion of hæmoglobin into bile pigment occurs outside of the liver (Mann),[7] probably through the action of the cells of the reticulo endothelial system. The introduction of a delicate test by van den Bergh [8] has shown that bile pigment (bilirubin) is normally present in the blood stream in a concentration of 1 : 400,000 to 1 : 1,000,000. We may look upon the epithelial cells of the liver, therefore, as excreting the bile pigment brought to it by the circulating blood rather than producing it by their own activity. Further, the amount of hæmoglobin available for conversion into bilirubin will depend on the rate of the red cell destruction (Rous and Drury),[9] which is high in the primary anæmias, and presumably greater in an individual with a normal red cell count than with a low count due to secondary anæmia. The depth of jaundice in any given case will depend on two factors, aside from variations in pigment excretion by the kidneys, the rate of red cell destruction, and the condition of the liver.

Under this conception of jaundice the important clinical changes therefore are those taking place in the blood stream. The tissue staining of gross clinical jaundice reflects only slowly and incompletely the variations of pigment concentration in the circulating blood (Rous, Peyton).[10] Since the amount of bile pigment (bilirubin) normally present in the blood plasma is considerably less than that at which clinical jaundice occurs, there may be recognizable degrees of retention short of actual jaundice. It becomes

important therefore to measure accurately the degree of bilirubin retention, since by this means we may demonstrate latent or occult jaundice.

The actual measurement may be made by means of van den Bergh's indirect diazo reaction which gives a violet color only in the presence of bilirubin, or by an estimation of the depth of yellow color of the serum. In the latter method the yellow color is compared with a standard solution of potassium bichromate 1 : 10,000 (Meulengracht),[11] in a Duboscq colorimeter (Maue),[12] or more simply with a series of dilutions of the same chemical in test tubes as suggested by Murphy,[13] the findings with regard to this arbitrary standard constituting the icterus index. Since the normal icterus index is from 2.5 to 6, there is range for an important degree of pigment retention before clinical jaundice appears at about 15. The yellow color of the serum may be due to other substances beside bilirubin. Van den Bergh's indirect or quantitative reaction is therefore more reliable as well as more delicate, but requires technical assistance. We have found Murphy's,[13] method, checked by the qualitative van den Bergh reaction, adequate for routine clinical purposes.

The estimation or bilirubin retention through the icterus index or van den Bergh test is of unquestioned value surgically, and deserves to take its place beside the guaiac test of the stools and the demonstration of red corpuscles in the urine. The finding of latent jaundice gives much the same general type of information, our attention is directed either to the biliary system and liver or to excessive red cell destruction, which is valuable in obscure cases if too much weight is not given to it. Naturally latent jaundice is more frequent in gall-bladder disease or septic processes in the liver than in peptic ulcer or renal colic. Further, there is now no need for argument as to whether a patient is jaundiced or sallow, it can be demonstrated beyond doubt. Finally, we have a means of measuring accurately the depth of jaundice by which we can follow the progress of disease, choose a favorable time for intervention, and estimate the effect of treatment.

The demonstration of latent or measurement of actual jaundice by these methods gives no hint as to the cause of the pigment retention. The prompt recognition of jaundice relievable by surgery is an important factor in lessening operative risk. The qualitative or direct van den Bergh test would seem to give the greatest aid in separating various types of jaundice. According to McNee,[14] jaundice may be due to excessive hæmolysis, as in pernicious anæmia or in familial jaundice, to toxic or infectious action on the liver epithelium, as in pneumonia, and after the administration of certain drugs, or to obstruction of the bile passages.

Van den Bergh [15] has demonstrated by means of his direct diazo reaction that the retained bilirubin causing jaundice may occur in two forms. In one form it gives prompt (maximal within 30 seconds)* violet color with his reagent. In another form it gives either no color, or only after long delay.

* In our experience, according to the technic of McNee,[14] the color change is rarely so prompt.

Experience has shown that the prompt reaction occurs typically in obstructive jaundice, and the delayed reaction in hæmolytic jaundice. He explains this on the basis that in obstructive jaundice the bilirubin has been acted on and altered by the epithelial cells of the liver and is subsequently reabsorbed, while in hæmolytic jaundice the excessive formation of bilirubin takes place faster than the liver cells can excrete it, hence it tends to accumulate in the blood unacted upon by the liver cells. In actual practice types of jaundice are found which give all gradations in speed of reaction between the prompt and the delayed. McNee [13] states that these intermediate reactions, to which the name of biphasic has been given, can be accounted for on the view that both the variety of the bilirubin which gives the prompt reaction and that which gives the delayed reaction are present in the serum together. He associates these biphasic reactions particularly with the cases of toxic and infective hepatic jaundice, and explains them by assuming that some bile pigment fails to pass through the damaged liver cells and passed directly into the blood, while the remainder which is excreted by the still active liver cells, is obstructed in the bile capillaries, and is reabsorbed into the circulation.

Here is a test which at first sight should be helpful in differentiating the cases of jaundice capable of being benefited by surgery. But even if the cases of obstructive jaundice are infallibly separated by the van den Bergh reaction, a surgical lesion is not necessarily present. Obstructive jaundice in the usual narrow surgical conception, possibly unconsciously influenced by the type of case in which surgery is useful, is due to compression or obturation of the extrahepatic ducts. But obviously obstructive jaundice can equally well be caused by obstruction of the biliary passages within the liver, due to inflammation, fibrosis, or metastatic malignancy.

The demonstration of obstructive jaundice, therefore, is not enough to bring cases within the surgical group. Should the finding of a delayed type of reaction influence us in advising operation? McNee [16] states that the qualitative reaction may enable a positive diagnosis of obstructive or hæmolytic icterus to be made and that as a rule in the commonest type of jaundice, the toxic and infectious group, no information of diagnostic or prognostic value is given to the clinician. Andrews [17] concludes that frankly obstructive can be distinguished from frankly hæmolytic jaundice by means of the test, but as a means of differentiating icterus from liver cell damage from other types of icterus the value of the method is slight. Our own observations, for which I am chiefly indebted to Dr. G. S. Speare, have shown not only that both the prompt and the delayed types of reaction may take place in catarrhal jaundice and in cirrhosis, but that the delayed type of reaction may occur in cholecystitis without duct obstruction and in a few cases with a low serum bilirubin apparently obstructive in character as shown by operation. Therefore, although the qualitative van den Bergh reaction is of value in clinical and experimental study of disease, as evidence for or against operation in the individual case it is distinctly subordinate to the clinical picture.

Since the demonstration by Abel and Rowntree [18] that phenoltetrachlor-

phthalein was excreted by the liver in the bile, much attention has been given to this dye test of liver function. When Rosenthal [19] changed the criterion of liver efficiency in dealing with the dye after intravenous infection from the excretion in the bile to retention in the blood stream, the test became relatively simple and direct. In actual clinical use, the method has certain limitations. While experimentally, as Rosenthal [20] has shown, dye retention is proportional to the amount of liver excised, in disease, only one phase of liver function is tested; no information is given, except by inference, as to the state of other liver functions. If the liver is unable to excrete bilirubin normally, so that it is retained by the serum, dye retention also with few exceptions occurs. While the degree of dye retention does not parallel absolutely the depth of jaundice, there is a general relation between the two. It is not yet apparent, that in cases of obstructive jaundice greater significance can be given in diagnosis or prognosis, to the degree of dye retention than to the amount of bilirubin retention as shown by the icterus index. Further, the use of phenol-tetrachlorphthalein in the doses usually recommended, 5 mg. to the kilo, is not without possibilities of harm. Thrombosis of the injected vein not infrequently occurs and general reactions have been reported. Maurer and Gatewood [21] and Rosenau [22] have called attention to the possibility of injury to the severely damaged liver. In a case shortly to be operated on this aspect is important.

The chief value of the method lies in the fact that dye retention may occur in cases where the serum bilirubin is within normal limits. Greene, McVicar and Rowntree [23] have shown that this retention may occasionally furnish the only evidence of metastatic nodules in the liver. During recovery from catarrhal jaundice and after the relief of obstructive jaundice, dye retention may persist longer than elevation of the serum bilirubin. Shattuck, Brown and Preston [24] state that the Rowntree-Rosenthal test seems to be of greater value than the icterus index in the diagnosis of cirrhosis and of malignant metastasis of the liver.

Since the introduction by Rosenthal [25] of a new dye, bromsulphalein, by means of which a test can be secured with a smaller dosage (2 mg. to the kilo), we have made use of it in a small number of cases. While it is too early to speak of results, we are encouraged to continue, both from the information secured as to diagnosis in occasional borderline cases of liver disease, and from the freedom from sequelæ.

The jaundiced surgical patient presents a complicated situation, in which disturbance of the kidneys and pancreas, dehydration, malnutrition, and sepsis may share as well as interference with the liver. While the information secured by the methods discussed is of much value, it does not constitute a short cut by which a diagnosis or an evaluation of the risks of operation may be arrived at. Knowledge of the condition of the patient gained through a thorough clinical study, including the chemistry of the blood and urine, must be considered of greater importance than direct tests of liver function. The most conclusive evidence of an obstruction of the extra-hepatic ducts is

a persistent absence of bile pigment from the intestinal tract. In prognosis, whether or not we may refer it to liver function, the most valuable sign is a delay in the coagulation time of the blood. But in tendency to hemorrhage, as in judging the state of the liver, we should be guided by suspicion rather than by actual demonstration. If such suspicion exists the pre-operative measures emphasized by Walters [26] should be employed, an abundant fluid and carbohydrate intake, given if necessary by rectum or by hypodermoclysis, and the intravenous use of calcium chloride.

BIBLIOGRAPHY

[1] Graham, E. A., and Cole, W. H.: Röntgenologic Examination of the Gall-bladder. J. A. M. A., 1924, vol. lxxii, p. 613.
[2] Mann and McGath: Arch. Int. Med., 1922, vol. xxx, p. 73.
[3] Bollman, Mann and McGath: Am. J. Physiol., 1924, vol. lxix, p. 371.
[4] Bollman, Mann and McGath: Am. J. Physiol., 1925, vol. lxxii, p. 629.
[5] Greene, Snell and Walters: Arch. Int. Med., 1925, vol. xxxvi, p. 273.
[6] Rich, A. R.: Physiol. Rev., 1925, vol. v, p. 182.
[7] Mann, Bollman and McGath: Am. J. Physiol., 1924, vol. lxix, p. 393.
[8] Van den Bergh and Snapper: Deutsch. Arch. f. klin. Med., 1913, vol. cx, p. 540.
[9] Rous and Drury: J. Exper. M., 1925, vol. xli, p. 601.
[10] Rous, Peyton: Am. J. Med. Sc., 1925, N. S., vol. clxx, p. 625.
[11] Muehlingracht, E.: Deutsch. Arch. f. klin. Med., 1920, vol. cxxxii, p. 285.
[12] Maue, H. P.: Surg., Gynec. and Obst., 1923, vol. xxxiv, p. 752.
[13] Murphy, W. P.: Boston M. and S. J., 1926, vol. cxciv, p. 297.
[14] McNee, J. W.: Quart. J. Med., 1922–23, vol. xvi, p. 390.
[15] Van den Bergh, A. A. H.: Der Gallenfarbstoff im Blute, Leiden, 1918.
[16] McNee and Keefer: Brit. M. J., 1925, vol. ii, p. 52.
[17] Andrewes, C. H.: Quart. J. Med., 1924–25, vol. xviii, p. 19.
[18] Abel and Rowntree: J. Pharmacol. and Exper. Therap., 1909, vol. i, p. 231.
[19] Rosenthal, S. M., J. Pharmacol. and Exper. Therap., 1922, vol. xix, p. 385.
[20] Rosenthal, S. M.: J. Pharmacol. and Exper. Therap., 1924, vol. xxiii, p. 385.
[21] Maurer and Gatewood: J. A. M. A., 1925, vol. lxxxiv, p. 935.
[22] Rosenau, W. H.: J. A. M. A., 1925, vol. lxxxv, p. 2017.
[23] Greene, McVicar, Walters and Rowntree: Arch. Int. Med., 1925, vol. xxxvi, p. 542.
[24] Shattuck, Brown and Preston: Am. J. M. Sc., 1925, N. S., vol. clxx, p. 510.
[25] Rosenthal and White: J. A. M. A., 1925, vol. lxxxiv, p. 1112.
[26] Walters, Waltman: Surg., Gynec. and Obst., 1921, vol. xxxiii, p. 651.

THE GALL-BLADDER OF 1926*

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The gall-bladder is still elusive as to some of its functions, and what has been learned concerning it, as well as the function of the biliary apparatus, continues to maintain our interest in it, if anything to a higher tension than ever. Abdominal surgery largely developed from 1890 to 1900, during the ten years following the decade of the discussion of the germ theory of disease and the practice of antiseptic and development of aseptic surgery: a period in which surgeons were constantly brushing up their knowledge of the anatomy of the gall-bladder, ducts and adjacent structures preparatory to operations on them. Without enlargement of the lymph-nodes of the ducts lesser degrees of gall-bladder disease could not be diagnosed or even recognized with any degree of certainty with the abdomen open, and most operations on it were performed following several attacks of colic. It was often necessary for the yellow flag of jaundice to be spread before adequate effort would be made to relieve the disease. Many laymen and even some medical men considered the attacks of colic neuralgia of the stomach unless the victim became jaundiced; to refute the suggestion of probable gall-stones they pointed to the absence of jaundice. The gall-stone was the essential factor, the real disease which in some unknown and mysterious manner had developed in the gall-bladder. Catarrhal jaundice was recognized as an infection of the biliary ducts, a disease occurring sporadically or occasionally, several cases in a community. Less was known of those not rare cases of jaundice showing epigastric soreness and pain in the back, with gastric symptoms, but without colic, chill or fever, in which disease of the head of the pancreas (either interstitial or hemorrhagic) causes obstruction of the duct. Surgeons saw obstruction of the common duct in all degrees of severity and in all stages of development following recurring attacks of colic due to Fenger's floating ball-valve stones. Blockage of the cystic duct and secondary infection caused empyema and thickening and contraction of the gall-bladder wall which forced stones into the common duct. This condition closely followed Courvoisier's observation that in the cases of stone in the common duct the gall-bladder was found contracted in 84 per cent. of cases. Jaundice due to obstruction of the lower end of the common duct, from other causes than gall-stones, usually dilated the gall-bladder. It was caused by cancer of the pancreas, stricture of the common duct, or tumor of the ampulla of Vater. Pathologists now reported added dangers from a fixed stone causing no pain, as usually only the moving stones cause colic. Several years after the cessation of such attacks of colic, painless jaundice might result from primary cancer of the gall-bladder and ducts spreading to the liver, but in association

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with gall-stones in nearly all cases. Preservation of the gall-bladder was the general surgical rule even when it was incised for stones fixed in the cystic duct, and much stress was laid on various suitable methods of opening the gall-bladder for drainage. A few surgeons developed the operation of cholecystotomy, removing stones and immediately closing the gall-bladder by suturing. Operations for relief of symptoms of gall-stones, as diagnosed, showed that there were other diseases of the gall-bladder besides gall-stones, such as the so-called acute abdomen, an inflammatory condition often associated with interacinar hemorrhagic pancreatitis and fat necrosis, commonly seen in obese patients. Catarrhal cholecystitis with thickening of the mucous membrane sometimes showing yellow lipoidal degenerated spots in the thickened dark-red mucosa (and from its appearance designated "strawberry gall-bladder"), or large and small mucous papillomas, were recognized. Past inflammation of the serosa was indicated by adhesions to the duodenum, colon, or omentum. Cholecystostomy with drainage for the latter condition frequently left the patient worse than before operation from the adhesions of the fundus to the abdominal wall and the traction colic they caused. In the meantime patients who had had gall-stones removed years before by cholecystostomy returned with former symptoms and the gall-bladder was again found filled with stones. In some cases three operations for stones were required, or a second operation for non-functioning gall-bladder, seen so frequently as a result of disease. Thus from 1910 to 1915, cholecystectomy was developed as the operation of choice. It was now generally appreciated that the gall-stone was the result of a condition in which the gall-bladder played an important part, and more and more investigative research was directed to the biliary apparatus. A knowledge of the causation of gall-stones and inflammation of the gall-bladder is said to be necessary for proper treatment. I do not agree with this as we have made all our progress in the medical and surgical treatment of gall-stones and gall-bladder disease without knowing the answer. The surgical treatment is satisfactory. Knowledge of the cause of the disease is essential for prevention of it and to make possible better care following operation; and all surgeons are interested in it.

The gall-bladder is present in most animals which secure their food from the surface of the ground. The leaf-eaters which are mostly antler-bearing and cast their antlers yearly have no gall-bladder. Other leaf-eaters like the elephant and horse also have no gall-bladder. The pocket gopher, living continually beneath the surface, has no gall-bladder, while the striped gopher, living beneath and feeding above, has one.

Embryologically the gall-bladder begins in a small nest of cells from which are developed the pancreas, liver, duodenum, and ducts. It occurs as a solid bud on the common duct which later becomes hollow and enlarges, and consists of four coats, mucous membrane, sub-mucous layer in which are large and active lymphatics, muscularis with elastic and connective tissue, and serosa, beneath which is a poor arrangement of lymphatic vessels. It is supplied by a large artery, the cystic, and a few vessels join it from its attach-

ment to the liver. The gall-bladder receives circulation with full heart pressure while the liver is supplied by a comparatively small artery to cells all alike working under low tension. The gall-bladder in man holds approximately 30 c.c. of bile, probably one-fortieth or less of the total amount of bile made in twenty-four hours. Early morning operations on the abdomen usually show the gall-bladder well filled (the fasting condition). The liver apparently makes bile at varying speed but constantly, and varying amounts pass into the duodenum according to the digestive activity. It is most active following meals until the food has left the stomach. Mann believes that from this time until the next meal the gall-bladder probably deals with most of the bile by filtration of it through its wall into the lymphatic tract. With his associates he has shown that tension is not the same in the gall-bladder and in the duct, indicating that the gall-bladder can contract and close the cystic duct at its juncture with the pelvis of the gall-bladder. The cystic duct is surrounded by muscle and usually has folds of mucous membrane which are alternately or spirally placed about the duct and were described by Heister, in 1782, as valves; yet some cystic ducts have no valves whatever. The cystic unites with the common duct at an acute angle or the hepatic duct is separated from the opening of the cystic duct by an intervening septum extending below the cystic. The gall-bladder not being like a rubber bulb can create no vacuum for suction. It is dependent then on the closure of the outlet of the common duct into the duodenum for bile to fill the viscus, through the cystic duct. Gage, in his examination of the common duct of the cat in 1879, showed that a sphincter existed at the outlet. Oddi made extensive research on many species of animals, and proved the presence of this sphincter. It is also found in types of animals which have no gall-bladder; having no gall-bladder they have proportionately slightly larger ducts.

It has been shown that the bile in the gall-bladder of man is approximately ten times as concentrated as it is possible for the liver to make it or as found in the hepatic ducts. Bile is rather essential for the digestion of fat, yet there is marked variation in the amount of fat in the natural foods in different types of animals which have gall-bladders. It is probable that the gall-bladder has control of its own cystic duct in order to cause pressure-filtration of the water or fluids of bile which pass to the blood stream through the lymphatics without coming in contact with the intestinal contents; also to work properly it should have control of the sphincter of Oddi in order to refill itself. Sweet and numerous others believe that under normal conditions little or none of the bile which enters the gall-bladder leaves it by way of the duct. He has demonstrated parietal pockets along the larger intrinsic and extrinsic hepatic ducts which might also act as filters if we can think of them as serving this purpose. The so-called glands of Luschka, little pockets in the mucous membrane of the gall-bladder, are undoubtedly not true glands. These correlated actions are probably somewhat like the law of contrary innervation propounded by Meltzer and act through the nervous system,

the sympathetic and parasympathetic. Whatever amount of bile is found in the gall-bladder should then represent ten times as much bile as has entered it. The flow of bile into the duodenum is said to be increased by intra-abdominal pressure which occurs by respiratory efforts. This probably has some effect but not in fish, because they respire through gills; the principle must serve varying conditions. Coffey showed that the common duct traverses the wall of the duodenum for from three-fourths to one and one-fourth inches. The rolling peristaltic waves during digestion would constantly milk the common duct and aid in delivery of bile when most needed. It is difficult to estimate the amount of exudate of mucus as a colloid formed by the mucous lining of the gall-bladder. After cholecystostomy, with a blocked cystic duct for any reason causing fistula, a considerable amount of clear mucus is discharged daily. Whether this mucus has the power of solvent action on inspissated bile has not been sufficiently studied. Aschoff showed that healthy bile itself has some power of absorption of gall-stones and that small stones placed in a healthy gall-bladder lose a considerable part of their weight during a few weeks. Blocking the lower end of the common duct without gall-stones will distend the gall-bladder and ducts. Within a few weeks, first dark bile, then inspissated bile, granular and thick, fills the gall-bladder and ducts, and in a few more weeks white bile as colloidal mucus alone is found filling the gall-bladder and ducts. Mann and Bollman, by ligating the common duct in animals, have shown that a noticeable increase in bilirubin is not found in the blood sooner than from twenty-four to thirty-six hours and jaundice does not show for approximately four days, indicating that the gall-bladder can filter a very large amount of bile. If the ligation is made and at the same time the gall-bladder removed, the same increased amount of bile salts is noticed in the blood in from three to six hours and jaundice appears in twenty-four hours. Sheard with spectrophotometric studies shows that it is increased in each fifteen minutes.

Nature has placed on each of the common, hepatic and cystic ducts at least one lymph-node and occasionally two. They have a definite size in health, and all surgeons who have paid attention to them have depended quite largely on evidence furnished by their enlargement for indications of an excess of filtration by the gall-bladder. The size of these lymph-nodes always depends on the degree of overwork or the degree of infection present.

For a few decades we have had surgical treatment of gall-stones and gall-bladder disease and previous to that the medical treatment; now medical drainage of the gall-bladder and ducts has been added. It is accomplished by passing a tube through the stomach into the duodenum and inserting a solution of magnesium sulphate or of oleic acid. This relaxes the sphincter and stimulates the flow of bile; gall-bladder bile evidently constitutes a part of this quantity of bile. Food passing from the stomach as chyme also stimulates the flow of bile with relaxing of the sphincter, while a 3 per cent. solution of hydrochloric acid applied to the duct area raises the duct pressure to over 800 mm. through spasm of the sphincter. There is very little (from

10 to 30 mm.) back pressure in the common and hepatic ducts of animals without a natural gall-bladder, and the same condition obtains after removal of the gall-bladder. The tension in the common duct taken under anæsthetic runs 75 to 100 mm. of bile; that in the gall-bladder varies from 100 to 200 mm. Therefore such a pressure is capable of filtering the fluids from bile and of increasing its salts to ten times its manufactured strength. Rough handling and crushing of the wall of the gall-bladder in forceps seem to check its activity of filtration. Thus fresh bile with dye (Graham-Cole test) does not enter the gall-bladder to show in the röntgenogram. Disease of the gall-bladder also checks its activity of filtration. Mann was able to show that chemical inflammation of the gall-bladder produced by injecting Dakin's chlorin solution intravenously, which has a selective affinity for the gall-bladder, greatly checks its activity of absorption, depending on the degree of injury produced. The liver has selective affinity for certain dyes, as was noted by Rowntree in 1914, in working on the chemical tests of renal and hepatic function. He showed that phenolsulphonephthalein was excreted by both the kidneys and liver and that a chlorin derivative, especially phenoltetrachlorphthalein, was handled solely and specifically, by the liver. This is the basis of the Rowntree-Rosenthal test of hepatic function. Mann has shown that when Rose Bengal dye is given intravenously 50 per cent. will appear in the gall-bladder within one hour; some of this appears in the gall-bladder when the cystic duct is ligated, indicating that it can pass into the gall-bladder from the vascular system either from the liver or the cystic artery.

The Graham-Cole test is commonly used to demonstrate gall-bladder disease with dyes excreted by the liver. A normal gall-bladder takes the dye-stained bile into itself through the cystic duct, and shows in the röntgenogram. If there is any interference with the passage of bile into the gall-bladder its outline shows but faintly or does not show at all in the röntgenogram. Single cholesterin stones may appear in a gall-bladder so little diseased, that it will show the dye. The modern method of giving these dyes by mouth is sufficiently effective and obviates the reaction often noted when they are given intravenously or by hypodermic. This test, however, should more frequently be reserved for the doubtful cases, difficult of diagnosis. Inflammatory conditions of the gall-bladder are infective and due to the toxins produced by the various bacteria.

Three routes of entrance of infection have been discussed: (1) Bacteria from the intestine enter the common duct and pass into the gall-bladder through the cystic duct; (2) they pass through the liver through the portal circulation and are not completely destroyed by the liver and pass into the gall-bladder with the bile; and (3) they are backed up through the lymphatic system of the gall-bladder, thus gaining entrance through its wall. These are all possible but not probable causes. Pure bile is not a good culture medium for types of bacteria found in gall-bladder disease. When inflammation is present and the bile contains 30 per cent. of serous exudate, it is a fairly good culture medium. This presupposes an inflammatory condition making the

gall-bladder and its contained bile vulnerable to the attack of bacteria. Infected material from the wall of an acutely inflamed gall-bladder carefully prepared by Rosenow to remove superficial contamination will give a culture of these bacteria. When they are intravenously injected into animals acute inflammatory disease of the gall-bladder results in over 70 per cent. of tests. These animals being healthy and not ready of themselves to develop gall-bladder disease soon recover from the local disease. The hæmatogenous route is undoubtedly the common one. The gall-bladder, once infected, becomes a probable focus for aggravation of existing disease of the heart muscle.

The normal liver is a peculiar dark red with a fairly sharp or axe-like edge. The abnormal liver found associated with gall-bladder disease and probably preceding the gall-bladder disease is darker, roughly mottled, often adherent to the parietal peritoneum or omentum from previous attacks of hepatitis; from its color, and rough and granular appearance it could be said to be in a state of biliary congestion or retention. If the sympathetic system now produced increased tension on the common duct through spasm of the sphincter of Oddi doubling its pressure, the gall-bladder could be made to overwork and filter an excess of bile fluids, leaving the residue considerably more concentrated than normal, in fact tangible and visible as bile sand, consisting of bilirubinate of calcium, bilirubin and bile salts with cholesterin. With but little increase in tension the duct may not relax during digestion and thus greatly increase the work of the gall-bladder and temporarily cause gray or light-colored stools. In some quick and fleeting attacks as seen in pregnancy, almost clear cholesterin constitutes the stone with but little change in the liver or gall-bladder. Gall-stones undoubtedly form quickly, even in a few hours through the stimulation of excessive fat or from toxins. Usually a new stone is formed, but occasionally an extra layer is deposited on a previously formed stone, the total material usually being less than that daily handled by a hen in forming the egg-shell. Thus stones are almost never found in the process of formation but they vary in density with their age in the same gall-bladder. Are the bacteria the cause of the condition, or do they reside in the gall-bladder wall because of some liver disease and become active under opportunity? Sometimes clumps of bacteria are found in the centre of gall-stones, but Rosenow's idea of selective affinity of bacteria for the gall-bladder wall through the circulation is undoubtedly the correct one as its interior should be as well protected as the hepatic and cystic ducts. With bacteria alone Rosenow has created minute gall-stones in the natural pockets in the wall of the gall-bladder of animals by intravenous injection of bacteria from diseased gall-bladders. A congested liver with diseased gall-bladder usually shows, above and about the attachment of the gall-bladder, whitened areas of connective tissue. This area is rich in lymphatics which are associated with those of the gall-bladder. It is a part of the filtration area used by the gall-bladder. This area is thrown into relief immediately after an intravenous injection of Dakin's solution of chlorin

into animals, showing chemical inflammation to be a counterpart of bacterial inflammation.

The study now becomes more interesting. A diseased gall-bladder overworked in filtration and with a bile-congested liver brought about by spasm, elevating the tension but not blocking the sphincter of Oddi, should accumulate residue; this should precede the development of gall-stones. I believe there is an increase in the percentage of cases of diseased gall-bladder, and appendix, and of gastric and duodenal ulcer, most of them not recognized until gross lesions have occurred. Appendicitis, formerly worthy of extensive discussion, is now accepted as a disease entity and operations on it are common. The more seriously it is found to be affected with chronic disease in middle age, the more probably will it be accompanied by disease of the gall-bladder or a duodenal or gastric ulcer.

The McBurney incision for appendicitis should only be made in children under sixteen years of age; over that age abdominal investigation is best made through a straight incision in the rectus and an infected appendix is best dealt with through a similar incision. There is undoubtedly an etiologic relationship between appendicitis and disease of the gall-bladder in middle life. There are few necropsies of persons aged forty or over in which the appendix is normal. This is also the case to-day with the liver and gall-bladder. Spasm of circular muscle occurs through the mild stimulation of the sympathetic, but may also be apparently of vascular origin, attributable again to the sympathetic.

Is it not possible that, varying with the individual, some defect or deficiency in food intake, still remaining to be discovered, may cause a spasm of the sphincter of Oddi, doubling the work of the gall-bladder filtration, often causing secondary spasm of the pylorus, or plaque spasm of areas of the stomach wall, with or without the association of appreciable gall-bladder disease, or that spasm of the circular-muscle bands, interfering with the circulation of local areas of the mucous membrane of the appendix or the colon in diverticulitis, makes such areas less resistant? The variation in activity, degree of virulence of the bacteria or lowered resistance would explain the difference in the acute or chronic character of the disease or the amount of destruction. Such reasoning would assign to bacteria the rôle of either primary or secondary agents of disease not necessarily in the gall-bladder wall but primarily in the intestine, frequently with additional foci in the mouth, the cervix uteri after the age of forty, and the prostate after the age of forty-five, it may be that we have overlooked the sympathetic nervous system as an associated agent of disease when locally influenced by one or more of several possible causes.

Is it not possible that spasm of circular muscle, originating in the sympathetic nervous system is the primary basis of many diseases of the appendix, of diverticulitis, of gall-bladder disease analogous to Raynaud's disease of peripheral vessels, or sudden spasm of the renal circulation? May not the sequence of gall-bladder disease be (1) spasm of the sphincter of Oddi, due

to some unknown cause, perhaps by food deficiency or toxins; (2) overwork in the function of filtration; (3) inspissation of bile; (4) altered nutrition of the gall-bladder tissue due to circulatory changes which are secondary to spasm, and (5) bacterial changes, the type of disease varying with the virulence of the organism, the nature of the local condition, duration and like conditions. In other words, may not sympathetic irritation and muscular spasm be at times a primary clinical factor worthy of further investigation?

Urticaria has long been considered as caused by some particular type of food which is toxic for the individual; others develop eczema or nasal irritation. Such individuals are fortunate as they are led to investigate and eliminate the cause. Similar manifestations of foods which are toxic to the individual unfortunately may not be evident externally. They cause diverticulitis of the colon and irritation of the sympathetic system, producing spasms of circular muscle, and producing appendicitis and gall-bladder disease secondary to long-continued biliary congestion. The vascular spasm seen in renal spasm and in Raynaud's disease serves as a link to attribute similar causes to these diseases and duodenal and gastric ulcer.

PROBLEMS IN GALL-BLADDER SURGERY*

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The mortality connected with cholecystostomy and cholecystectomy will depend largely upon what operation is done in the serious complications of biliary disease so in order to more clearly grasp the whole problem I think the causes of death in this group of operations should be thoroughly studied.

There are four outstanding contributory causes of death in this field. (1) Long standing jaundice. (2) Cardio-vascular renal disease. (3) Abscess around cystic duct. (4) Carcinoma.

The other chief contributory causes are:

(5) Lung complications including embolus. (6) Associated pancreatitis. (7) Hepatitis acute. (8) Liver stones. (9) Peritonitis.

My own mortality has been largely confined to this group. Most of these causes of death are so well understood it is unnecessary to more than mention them. Some of them, however, I think need further emphasis.

In studying my own deaths I have been struck with the number of deaths apparently due to heart complications, particularly in aged people. Immediately you will say that this is an easy way of avoiding the real cause of death, but the cases to which I refer for the most part came to autopsy. The picture soon after operation is one of acute cardiac dilatation; pulmonary œdema, enlarged heart, with no abdominal symptoms. Some had more or less urinary suppression associated with œdema but I have felt the real condition was cardiac because autopsy showed very little outside of chronic interstitial nephritis with cardiac dilatation. I am more and more impressed with this conclusion that certain hearts particularly in the aged, which do not show any clinical evidence of cardiac disease sometimes are much more impaired than some which do. Seldom do we experience any difficulty with compensating hearts with clinical evidence of disease.

Much has been written regarding embolic processes in the lung but I am convinced it is a much more frequent incident than we have heretofore believed. So many times one sees from the second to the fifth day cases developing pulmonary symptoms usually mild temperature 100–101, some cough, sometimes bloody, they usually recover. These are usually ascribed to the anæsthetic, but I am sure they are embolic in character. Certainly pulmonary embolus is a much more frequent cause of pulmonary complications than usually supposed and is a definite cause of death in a certain percentage of cases.

Massive collapse of the lungs I have not seen in any case or at least did not recognize it.

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Abscess around the cystic duct is a very serious disease. I was amazed to read in Deaver's book it carries an operative mortality of over 30 per cent. These of course ultimately must have cholecystectomy done but I wonder, in view of the very high mortality, if it would not be wiser to do a two-stage; contenting ourselves with mere drainage at the first operation.

As one studies this group, where the large percentage of deaths occur, one is surprised to find the number where the mortality is beyond our control. Any series of cases which include a fair proportion of cases in this group is sure to have a large death rate, consequently any discussion regarding mortality in cholecystectomy and cholecystostomy is at least unscientific unless we know which operation is done in these complications of gall-bladder disease. In my own series of five hundred cases, cholecystostomy has a higher mortality, merely because I have used this operation in the complicated cases.

I am thoroughly convinced that in the uncomplicated disease of the gall-bladder the mortality in both operations is so low it ceases to be a matter for controversy. The question has to be settled on other lines such as permanent cures, and the effect of both operations on diseases of the liver and pancreas.

Possibly we can start on a common ground by stating a few of the supposed "settled problems." I will mention a few of these although with some of them you may disagree.

(1) While infection may not be present inside the gall-bladder it may exist in the wall of the gall-bladder. Experiments of Rosenow and confirmed by many others together with clinical experience seem to substantiate this opinion.

(2) Stones recur after cholecystostomy.

(3) Mortality is so low in uncomplicated diseases of the gall-bladder with or without stones in both cholecystectomy and cholecystostomy, decision in favor of one or the other ought to rest upon other factors.

(4) Cholecystectomy is obviously the operation of choice.

(a) *Stones in Cystic Duct.*—The frequency of stricture here necessitating future cholecystectomy would seem in the absence of abscess to make primary cholecystectomy imperative.

(b) Stone in cystic duct with local abscess. Cholecystectomy is imperative whether it be done in one or two stages of operation.

(c) All forms of gangrenous cholecystitis.

The "unsettled problems" might be subdivided into:

(1) Those in which the majority of surgeons agree on the correct procedure.

(2) Those in which the majority of surgeons are more or less in doubt.

In the first group, I believe the majority of surgeons prefer cholecystectomy in:

(1) Adhesions around gall-bladder without other evidence of disease.

I am sure I am not always able to tell what cases are due to disease from infection of the gall-bladder or to the so-called congenital adhesions. In the presence of clinical evidence of gall-bladder disease I believe these cases should

have a cholecystectomy done, on the other hand, I am sure some cases have congenital adhesions around the gall-bladder which produce no symptoms. Here the gall-bladder should be left alone. I hope the discussion will shed further light upon how to distinguish between the normal and the abnormal gall-bladder in the presence of moderate adhesions without other evidence of disease.

(2) Gall-bladder with stones confined to the gall-bladder. There has been so much discussion upon this subject that I hesitate to bring it up at this time. From personal observation and the literature I am quite convinced the very large majority of surgeons to-day prefer cholecystectomy. I presume a small minority will continue to do simple drainage. The object of this paper, however, is to emphasize the importance of the complicated case, rather than the uncomplicated, as I personally believe in the absence of complications as jaundice, old age, bad risks, the question is almost settled in favor of cholecystectomy.

(3) Gall-stones with a low grade of biliary hepatitis. Much has been written of late on this subject regarding first its frequency and second the necessity of liver drainage in these cases. I have no doubt more or less of a low grade liver infection is present in most cases of infected gall-bladders but I am sure they are cured by cholecystectomy.

(4) With stones in the common duct and a contracted—non-functionating gall-bladder cholecystectomy with common duct drainage, should be done because the gall-bladder is useless for any subsequent procedures. Usually the gall-bladder is a small contracted organ with a large amount of scar tissue which if left can only be a source of trouble and of no possible benefit for future operative anastomosis.

In the second group where I think surgeons are more or less in doubt, the decision seems to me to be much more difficult.

(1) In the common duct stones with an apparently functioning gall-bladder, the 15 per cent. (Courvoisiers law), if we are sure all stones are removed from the common duct cholecystectomy with drainage of common duct is a safe procedure. However, complications in these cases are so frequent that probably in most instances cholecystostomy with drainage of common duct is the operation of choice.

(2) Stones confined to the gall-bladder, complicated by jaundice. The jaundice I believe is due to an associated infective cholangitis. I presume most surgeons here would believe in simple drainage but if we believe that tying off the cystic duct causes better drainage by forcibly dilating the sphincter of Oddi, then cholecystectomy should be done. Personally I am in doubt but usually do a cholecystostomy when jaundice is present.

(3) Chronic pancreatitis with or without stones in gall-bladder.—Again this question depends on the ultimate solution of the effect of tying off the cystic duct on the sphincter of Oddi. Chronic pancreatitis is a very unsettled problem. I think that Warthen's opinion that these are largely syphilitic in origin is an error because we have treated many without improvement.

I presume the severe grades of disease which similate malignancy ought to be treated by drainage, either external or into the stomach or duodenum, while possibly the milder forms ought to have a cholecystectomy.

(4) Subacute pancreatitis with areas of fat necrosis is a very difficult problem. Of course all gall-bladder complications should be treated in the usual surgical manner but just what to do with the pancreas is a disturbing problem. I am inclined to believe that these mild subacute cases of pancreatitis might be divided like the old adage into those who get well and those who do not. Is the pancreatitis really due to associated infection in the biliary system or obstruction to the pancreatic ducts? If due to the former I can see where biliary drainage in some form would be indicated, but if to the latter I cannot see the purpose of it. Drainage of the lesser sac in the absence of localized areas of hemorrhage seems almost futile. Much experimental work has been done to prove these cases are due to obstruction. We carried on many experiments on cats and found although the cystic duct was quite large the common duct was so fine it was almost impossible to force anything through it. Consequently I view with considerable doubt conclusions based on these premises. Is it not much more likely the disease is either metastatic from blood infection or as Deaver views it, direct extension through the lymphatics?

The acute hemorrhagic forms of the disease present an entirely different situation. Here the mortality is exceedingly high and the less done, with ample drainage, would seem to be preferable.

(5) Carcinoma of the pancreas and Ampula.—If we are sure of the diagnosis I feel those cases should not be operated upon. The difficulty of distinguishing between common duct stones and carcinoma of the pancreas, especially early, is so great, that operation is advisable in most instances for diagnosis. If at operation the diagnosis of malignancy is positive one has the choice of doing simple closure of the abdomen or some form of anastomosis between the gall-bladder and preferably the stomach. Cholecystostomy is I think a mistake. Patients almost invariably die much more rapidly than if no operation were performed.

In considering the question of hepatitis there seems to be a good deal of controversy. Of course it necessarily follows if you have gall-stones with an infected gall-bladder you probably have some associated liver infection. In fact the frequency with which actual stones form in the liver is not sufficiently emphasized. I presume the term biliary cirrhosis is as good as any other, but this is an entirely different pathological entity than acute hepatitis which I desire to emphasize. A biliary cirrhosis is cured by treating the cause, namely, disease of the biliary system, but acute hepatitis is not influenced by similar treatment because the infection is proximal to the gall-bladder and ducts.

Some cases I have seen have been to me very unusual, in fact it seems I have never noted any until the past few years. They have begun with fever, later jaundice and usually chills. The temperature varied from 101–104, and followed the usual septic type. Chills had no regularity. Jaundice has almost always been present to a varying degree. At operation the varying complica-

tions were present in the gall-bladder but treatment of it had no influence on the condition in the liver.

The disease ran its course regardless of cholecystectomy or drainage, usually ending in death. The liver has varied from a moderately large liver to a very small one. The pathological reports varied. Doctor Roman in three fatal cases reports. (1) Interstitial hepatitis with jaundice of liver parenchyma. (2) Cholangitis with biliary cirrhosis. (3) Acute cholangitis of smaller intra hepatic ducts. Degeneration of liver parenchyma with bile stasis with slight fibrosis and slight reduction in size of organ. Two cases were re-opened after several weeks, on the advice of the medical attendant thinking stones were overlooked in the common duct. They had chills and temperature at irregular intervals simulating common duct stones. Both cases showed very extensive adhesions around the liver, but no stones were found. The whole pathology of liver infection seems at best poorly understood. It would seem as if at one end we had mild biliary cirrhosis and the other end acute yellow atrophy with varying grades including infectious jaundice intervening.

Finally should we not view the whole subject of biliary surgery with a broader vision, than simply a conflict between cholecystectomy and cholecystostomy. The mortality in both is so small in the uncomplicated case that it need not be considered. The real problem is if possible to definitely establish the correct procedure in the associated complications of duct, liver and pancreatic disease.

DANGERS INCIDENT TO CHOLECYSTECTOMY*

AN ANALYSIS OF 575 CASES OF CHOLECYSTECTOMY AND CHOLECYSTOSTOMY

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The advent of the Graham method of cholecystography as a definite aid in the diagnosis of disease of the gall-bladder has already resulted in, and no doubt will continue to cause an increase in the number of cholecystectomies performed by all surgeons, good and bad alike. Numerous contributions advocating (and justly so) cholecystectomy as a procedure of choice in most instances of cholecystitis except in the presence of jaundice or an acute inflammatory process, has also shared in this increase of gall-bladders removed. Yet it is well to remember that the surpassing merits of cholecystectomy holds true only in the hands of an experienced abdominal surgeon. How infrequently failures are recounted and yet it is not from the perfect operation, easy excision of the viscus without alarming post-operative rise of temperature or prolonged bile drainage that much is learned; it is from those cases where we err in diagnosis, have a stormy post-operative course, and deaths that we really gain in knowledge and feel that we go ahead.

This article proposes to point out a few dangers of cholecystectomy and to analyze immediate post-operative results, laying particular stress on a group of cases in which the cause of death is unknown. From January 1, 1910 to April 1, 1926 a period of sixteen years and three months, there have been performed on the Second Surgical Division, Roosevelt Hospital 470 cholecystectomies and 105 cholecystostomies. Immediate operative mortality (patient dying while in the hospital) 35 or 6.08 per cent. of the combined groups of 575 cases; 241 have had a recall note since being discharged from the hospital; a percentage for recall of 41.9 per cent. The results of our follow up on the 241 patients are:

Two hundred and nine had cholecystectomies done, while cholecystostomy has been performed on the remaining 32,

Heard from by letter or verbal note from operating surgeon 165,

Examined at hospital by some member of the staff 76,

Of the 209 cholecystectomized patients 182 or 86.1 per cent. reported being well without symptoms or further operations.

Three of the remaining 27 had been operated upon elsewhere for stones in the common or hepatic ducts; three reoperated for stricture of the common duct and 21 complained of digestive disturbances or pain in the right upper quadrant of the abdomen. No persistent biliary fistulæ reported.

* Read before the New York Surgical Society, April 28, 1926.

Of the 32 patients heard from upon whom cholecystostomy was done, 18 or 56 per cent. had to be reoperated, 11 of these 18 having cholecystectomies

last recall note—cured	1 month	after discharge from hospital	30
last recall note—cured	2 months	after discharge from hospital	12
last recall note—cured	3 months	after discharge from hospital	3
last recall note—cured	5 months	after discharge from hospital	6
last recall note—cured	6 months	after discharge from hospital	9
last recall note—cured	10 months	after discharge from hospital	8
last recall note—cured	1 year	after discharge from hospital	29
last recall note—cured	2 years	after discharge from hospital	25
last recall note—cured	3 years	after discharge from hospital	12
last recall note—cured	4 years	after discharge from hospital	11
last recall note—cured	5 years	after discharge from hospital	15
last recall note—cured	6 years	after discharge from hospital	4
last recall note—cured	7 years	after discharge from hospital	6
last recall note—cured	8 years	after discharge from hospital	6
last recall note—cured	10 years	after discharge from hospital	4
last recall note—cured	13 years	after discharge from hospital	2
		Total	182

performed and 6 choledochotomy as well as a cholecystectomy. One had a second cholecystostomy six months after the first drainage operation and four months later a cholecystectomy, since this last operation nine years ago he reports by letter that he has had no abdominal discomfort of any kind.

Hemorrhage.—By far the most common cause for concern in the process of removal or immediately thereafter is hemorrhage. The reasons for this apprehension are numerous, first—an anomalous vessel is cut and its bleeding stump difficult to locate; second—a normally placed but friable cystic artery that has not been transfixed by ligature prior to removal of the bladder and the vessels slips through the clamp or is troublesome to reclamp and properly ligate; third—inadvertent injury to the portal vein in incising the common duct for exploration (it is much safer to first employ an exploratory needle) or injury to the hepatic artery in an attempt to clamp the cystic artery which has slipped away; fourthly—profuse bleeding from the gall-bladder sulcus.

Where the cystic artery has been clamped, doubly transfixed with chromic catgut and the gall-bladder sulcus carefully sutured over, we have had in our series during the last six months three instances where due to persistent and violent vomiting, troublesome hemorrhage resulted; either from a transfixed ligature that slipped or bleeding from a reopening of the gall-bladder sulcus, necessitating in all three cases blood transfusions with recovery.

Of our thirty-three deaths four have been definitely due to hemorrhage. An obese woman of forty-six years, weighing 260 pounds with a large distended gall-bladder filled with stones, also stones in the common duct, a cholecystectomy with exploration of the common duct with removal of stones, cystic artery and duct ligated together with three transfixion sutures of chromic catgut. Common duct drained. Clamp had to be left on what was taken to be

an oozing cystic artery. This in all probability was an oozing aberrant artery. Anterior abdominal wall drainage. Patient died from hemorrhage twenty-four hours after operation. Another woman of forty-seven, hydrops of gall-bladder, cystic duct occlusion, cirrhosis of liver, splenomegaly, ascites; opening made into a large vein in exploring hepatic duct, considerable hemorrhage, death twelve hours after operation. The third patient, a woman of thirty-six, enlarged gall-bladder containing stones, cholecystectomy, three transfixion sutures of chromic catgut to stump of cystic artery and duct, died on the fifteenth day post-operative. Comment on course note " Patient undoubtedly a hemophiliac." The fourth patient, a woman of thirty-two with an enlarged thick walled gall-bladder with stones; cystic artery and duct transfixed and ligated with chromic catgut. Drain to Morrison's pouch. Death from hemorrhage in twenty-eight hours.

Injury to Bile Ducts.—This mishap only occasionally causes immediate danger to the patient, later as a rule a reconstruction operation on the bile ducts has to be carried out. Knuckling up of a portion of the anterior wall of the common duct in a low ligation of the cystic duct although rarely done, still on increasing jaundice due to partial or even complete occlusion of the duct is attributable to this faulty step in technic.

As far back as 1798, Mathew Baillie [1] described extrahepatic ducts, other than the common bile duct the hepatic ducts and the cystic duct. He cites the finding of a short canal between the gall-bladder and the small end of the stomach which in all probability was a spontaneous cholecyst-gastrostomy. Holman [2] has shown that anomalous branches of the hepatic ducts may be cut in the course of a cholecystectomy and unless discovered may be the source of a distressingly prolonged biliary drainage, also he suggests as another cause of prolonged bile drainage, the opening up of small biliary passages especially so if much liver tissue has been traumatized in removing the gall-bladder from its bed.

Injury to the hepatic ducts to a more or less degree not infrequently happens in trying to dislodge a stone caught well up into the liver end of one of the ducts. Ingenious devices have been brought forward to bridge over or short circuit about defects in the common duct.

In our 470 cases of cholecystectomy the common duct was opened in fifty-four with four deaths two of these four patients that died having previously had cholecystostomies performed. In a report that is to appear later from the Second Surgical Division in regard to the common duct cases, it will be shown that from 1915 to 1925, of the fifty-one choledochotomies done during that period cholecystectomy was done in twenty-five, cholecystostomy in ten, and cholecyst-duodenostomy or cholecyst-gastrostomy in eight.

Post-operative Pneumonia.—Post-operative pneumonia was the cause of death in seven of our immediate mortality list. It took its toll anywhere from three to twenty days post-operative in the seven cases. One was in a cholecystostomy for rupture of the gall-bladder, temperature 103.6 when

operation was begun. In two cases besides cholecystectomies being done gastro-enterostomies were performed for the presence of duodenal ulcers. The other four followed simple cholecystectomies; however, one of these had had a cholecystostomy done three months previously. Immediately following the last operation her temperature rose to 105 degrees and broncho-pneumonia developed in latter part of the second or early part of the third day post-operative. Post-operative pneumonia does not apply particularly more as a danger in cholecystectomy than it does in any upper abdominal surgical procedure. It is listed as having had a considerable place in our mortality list.

Peritonitis.—Peritonitis resulting from the removal of especially acutely inflamed partially gangrenous or ruptured gall-bladders is in our experience a grave danger and in such cases cholecystostomy is the operation of choice. We do not advocate a removal operation in that group known as the acute gall-bladder for the reason that we had several deaths which we considered attributable to this procedure. We at the same time feel the responsibility of allowing a beginning gangrene of the inner coats due to pressure of a large single stone impacted in the cystic duct go to a more complete gangrene with subsequent rupture; yet we believe it is far better that they be observed for twenty-four or thirty-six hours or even longer to see whether or not the temperature, pulse rate and blood count will diminish indicating a "cooling off" as it were of the acutely inflamed viscus and thus making it safe to do a cholecystectomy. If after thirty-six or forty-eight hours the temperature remains elevated, rapid pulse, general appearance not improving, we do a cholecystostomy often under local anæsthesia believing frequently that the least we do is the best we do. In four of our cases peritonitis has been given as the cause of death, one died in five hours where the gall-bladder had already become gangrenous and had perforated, definite right upper quadrant peritonitis, cholecystostomy was performed. The second case, a large distended acutely inflamed gall-bladder in which the cholecystectomy was done, died on the second day. It was thought afterwards that if a drainage procedure had been carried out this patient would have lived. The third case was complicated by a subhepatic abscess present at the time of operation and a spontaneous cholecystoduodenostomy; a cholecystectomy and duodenorrhaphy performed; patient died twenty-four hours post-operative. The fourth case a cholecystectomy, in a woman of sixty with a large distended inflamed gall-bladder; death resulting on the fifth day due to sepsis.

Immediate Operative Mortality of Unknown Origin.—In only one instance of our entire list of cases that died while in the hospital was there any note made of there being an autopsy performed. There were three cases that died within forty hours with immediate hyperpyrexia one 107.2 degrees another 106 degrees and the other 107 degrees; hemorrhage, peritonitis, pneumonia, embolism were all ruled out clinically, in all cholecystectomy was the procedure. These were not the acutely inflamed type but simply cases with symptoms of prolonged chronic cholecystitis with calculi in the gall-bladder

in otherwise healthy women, not jaundiced. In one a cholecystostomy had been done one year previously. According to the operative notes the procedures were carried through without difficulty in fact two noted as being extremely easy. All three were drained, one through the upper angle of the wound, the other through lateral stab wounds with tight closure of the anterior abdominal wound. It seemed that immediately the operation was finished the temperature began to rise and reached exceedingly high levels with an accompanying rapid pulse rate. Although no mention is made of unusual liver traumatization except in one instance we believe these particular cases died from absorption of either diseased or chemically altered liver cells or toxic bile. The appearance or consistency of the liver not noted.

It is a startling and helpless situation to follow to its quick termination one of these catastrophies—the last one of these three here reported occurred in a young healthy vigorous Greek woman of thirty-five, with a definite and classical history of diseased gall-bladder for a period of over three years without jaundice, heart, lungs, kidneys normal, cholecystography revealed numerous shadows indicative of stones in a slightly enlarged gall-gladder. Operation upper right rectus incision and easy and splendid exposure of gall-bladder and ducts; the cystic artery and duct fully exposed, comfortably handled and twice transfixed with chromic catgut before being cut across and the third ligation of the duct and artery made by transfixion and tying after removal of the clamp and the gray-walled, stone-filled gall-bladder; the excision being easily carried out from below upward. The liver bed from which it was removed was rather broad, however, with only moderate oozing, the sulcus sutured over with the stump of the cystic artery and duct securely tucked and sutured into it at its lowermost angle, so dry was the area that it was remarked to be an ideal case for closure without drainage, however, a lateral stab wound to flank, wrapped tube drain to Morrison's pouch and a tight closure of the anterior abdominal wound was done. Immediate precipitous rise of temperature to 106 degrees at the termination which took place in forty hours. Pulse rate rose steadily with temperature curve to 154 no signs of pneumonia clinically or from portable X-ray films, a dressing done the drain loosened and withdrawn a short distance, a slight amount of bile-stained secretion on the dressing. No evidence whatever of hemorrhage.

Heyd and Killian [3] in their thorough and comprehensive monograph on "The Liver and Its Relation to Chronic Abdominal Infection," have observed "three clinical states that supervene after operation on the gall-bladder and biliary system" that are not due to hemorrhage, shock, gastric dilatation or embolism. In their opinion they were connected in some way with an impaired liver function, either a disturbed liver metabolism, a liver dysfunction or a liver insufficiency. Their first group corresponds to the three cases just cited in our series which were not of the infectious class but were of the group where the operation seemed most likely to have "liberated certain deleterious products the whole mechanism suggesting a complete and rapid cessation of liver

function." These patients regain consciousness slowly from the anæsthetic; characteristics of a vasomotor depression appear; although not restless as from bleeding, they early show signs of delirium which by the end of thirty-six hours gradually develops into a coma, and death ensues in the following twelve hours. It is now generally accepted that cholecystitis whether it be acute or chronic is only a part of an infectious process in the liver and pancreas, whether it starts first as a cholecystitis or a hepatitis is a question of dispute. We are quite certain of the existence of an extensive net work of lymphatics between the gall-bladder and the liver, therefore, it seems reasonable to presume that in a gall-bladder removal numerous lymph channels are opened and are so impaired permitting the absorption of toxins from diseased liver cells that the entire lymphatic system of the liver may react unfavorably to this disturbance resulting in a grave dysfunction. Should the operation be difficult consuming much time with a prolonged exposure to the air of the liver surface untoward effects may result in the chemical function of the liver for hours following the procedure. Crile [4] has shown that when the temperature of the liver is reduced one degree, the chemical activity of the organ is reduced 10 per cent. He has demonstrated that when the abdomen is opened, the temperature of the liver falls 1½ to 3 degrees even though the liver itself is not exposed directly. He furthermore states that "when, as the result of the exhaustion incident to disease, the chemical activity of the liver has been reduced to 10 per cent. of its normal capacity, death will occur if at operation the temperature of the liver is reduced by 1 degree." We believe that these disasters are caused by the sudden liberation of either toxins from or pieces of chemically altered liver cells themselves into the general circulation; or perhaps from a stirring up of infected bile in the intrahepatic ducts due to operative manipulation; followed by rapid absorption which appears to overwhelm the patient with resultant delirium, coma and death. The partial cessation of liver function from the shock of actual removal of the external biliary viscus from its bed and exposure of the liver surface no doubt play a rôle in these cases. The mortality rate following cholecystectomy due to disturbed liver function can be lowered by the proper selection of cases. The Rountree-Rosenthal dye test is of value in determining hepatic function. In surgical cases with jaundice it aids in estimating the activity of the liver parenchyma and should be undertaken pre-operatively in all cases of biliary tract disease in uncertain surgical risks to decide whether a removal or drainage operation should be done. The quantitative estimation of the icterus index is of decided help in measuring the function of the liver. The intravenous injections of 5 cm. of a 10 per cent. solution of calcium chloride as suggested by Walters [5] increases the operability in the jaundiced cases; and the preoperative precaution of forcing fluids, carbohydrate diet and glucose by mouth has added much to the safety of all gall-bladder operations. Restoration of failing hepatic function is essential if these sudden unexplainable deaths are to be eliminated.

Other More Obvious Dangers.—In our immediate mortality list other causes of death were from pulmonary embolism occurring in four cases; one instance of acute cardiac decompensation on the second day post-operative in a man of sixty-six; one intestinal obstruction, type or actual cause of the obstruction undetermined; another from bilateral post-operative parotiditis in a young woman of twenty-seven; acute nephritis on the fourteenth day claimed another; one put down as a "cardiac death" fourteen hours after operation; another from acute exudative nephritis. A woman of fifty-six years upon whom a choledochotomy and cholecystectomy were done and also the drainage of a pancreatic cyst; necropsy revealed pancreatic cyst, interstitial pancreatitis; fatty necrosis of retroperitoneal tissue; and acute exudative nephritis. One death from sepsis of the anterior abdominal wall on the ninth day, erysipelas having developed, extending to the right from the drainage tract which was at the upper angle of the wound. A man of forty-three with a small contracted gall-bladder, cholecystectomy closed without drainage of any kind. Temperature 105 degrees afternoon of operation; death on fourth day, cause not noted in history, perhaps a peritonitis. This was the only one of our twenty-two cases closed without drainage that terminated unsuccessfully. One died of what was designated as a post-operative colæmia. On the fifth day a cholecystectomy, a choledochotomy and a duodenorrhaphy for ulcer of the duodenum was performed. An acutely inflamed gall-bladder was removed in a woman of fifty-four, death on fourth day, "probable sepsis" entered into record as cause of death. The remaining fatality was attributable to a partial gastrectomy Billroth II for carcinoma of stomach, a cholecystectomy was also done. The patient died seventy-two days after operation, the cause of death exhaustion.

In this list of thirty-five deaths there were only three in which cholecystostomy was performed, an immediate operative mortality of about 5 per cent., comparing this finding with other immediate post-operative mortality charts it seems unusual not to have had a higher mortality from cholecystostomy. All three were desperately ill patients of over sixty-two years of age.

As to secondary operations in which cholecystectomy was performed, we had four cases; previous procedures of cholecystostomy having been done one year, eight years, four months and six months; these four are of course taken from the immediate mortality chart.

The cystic artery was ligated and transfixed with three different strands of chromic catgut in twenty-seven instances with two strands in only two of the cases, no ligature or suture of the cystic artery in one case due to the friability of the artery; this was in an acutely inflamed partially gangrenous gall-bladder where the cystic artery and duct tore out of the jaws of the clamp and tamponage had to be resorted too. In three no mention was made of the treatment of duct and artery. A subhepatic abscess noted in one case. An abscess between the liver and anterior abdominal wall in another and cirrhosis of the liver in still another. In thirty-two, lateral stab wound drainage was established, the rest were drained through the anterior abdominal wound.

SUMMARY

1. Four hundred and seventy cholecystectomies; thirty deaths. Immediate operative mortality of 6.3 per cent., 105 cholecystostomies, five deaths, immediate operative mortality approximately 5 per cent.

2. Follow up on 241 cases—a percentage for recall of 41.9 per cent. Cholecystectomy cases 209, 182 or 86.1 per cent. reported well, symptom-free, six of remaining twenty-seven reoperated. Twenty-one not cured of complaint.

3. Cholecystostomy cases heard from thirty-two; 18 or 56 per cent. reoperated.

4. Four fatalaties from hemorrhage. Anomalous arteries and ducts are occasionally encountered. In our 470 cases common duct opened in fifty-four with four deaths.

5. We do not advocate cholecystectomy in the acutely inflamed gall-bladder, preferring cholecystostomy.

6. In that fortunately small but baffling group of cases that end fatally within forty-eight hours of unknown cause, we believe, are due to absorption of the toxins from chemically impaired liver cells or infected bile from the intrahepatic biliary passages,

7. Other causes of death in our immediate mortality list:

Pulmonary embolism	4 patients
Acute nephritis	2 patients
Intestinal obstruction	1 patient
Acute cardiac decompensation	1 patient
Bilateral parotiditis	1 patient
"Cardiac death"	1 patient
Erysipelas anterior abdominal wall	1 patient
Exhaustion following partial gastrectomy, Cholecystectomy done at the same time	1 patient
"Probable sepsis"	1 patient
Colæmia	1 patient
Bile peritonitis	1 patient

THE SURGICAL MANAGEMENT OF THE COMPLICATIONS OF CHOLECYSTITIS *

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Cholecystitis usually begins as a chronic insidious process, the inaugural symptoms of which are disregarded by the patient and may escape the attention of the physician. Recognition of the early symptoms and prompt surgical treatment secure the best results with a minimum of risk. The recurrence of symptoms in a definitely small percentage of cases after cholecystectomy is usually the result of preëxisting complications. The surgical mortality of cholecystitis and its complications walk hand in hand. Cholecystectomy is a highly satisfactory operation because when performed early it removes the disease. Cholecystostomy is, and always will, be a useful operation, not because it saves the gall-bladder, but because it is a simple and safe method for relieving acute symptoms and providing drainage.

Acute, subacute and chronic cholecystitis are as a rule readily differentiated, but discrepancy between the clinical and pathological findings is not uncommon and the diagnosis of acute cholecystitis is often made only after the abdomen has been opened. A patient may be acutely ill with fever and prostration following an attack of pain in the upper right abdomen and at operation the pathology disclosed does not adequately explain the symptoms. Sometimes with mild symptoms and no constitutional disturbance the exploration discloses intense inflammation of the gall-bladder with œdema and many fresh adhesions. In a third group, the systemic reaction with local pain, tenderness, rigidity and sometimes a palpable mass points unmistakenly to acute cholecystitis and the diagnosis is confirmed by the pathology disclosed. Acute cholecystitis is surgical but when possible operation should be deferred until subsidence of the acute attack. During the acute stage there is likely to be a general portal infection which simmers down to localize in the gall-bladder. The surgeon, however, must be on the alert to detect any untoward symptoms indicative of perforation or suppuration which will demand immediate interference. Operations carried out on the acutely inflamed gall-bladder which is white, distended, thick, œdematous and surrounded by adhesions require accurate and thorough technic. Whenever possible such a gall-bladder should be removed, for, as in a case of acute inflammation of the appendix, it gets rid of the disease. The operation is tedious because of inflammatory exudate around the neck of the gall-bladder which obscures the landmarks and predisposes to traumatic injury of the main ducts. By cutting through the tissue just below the neck of the gall-bladder the cystic artery

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and cystic duct are divided and can be picked up separately and ligated. They do not retract because of the surrounding inflammatory exudate. Of course, when these structures can be accurately identified, it is better to clamp them before cutting. By careful dissection dividing the anterior layer of the gastro-hepatic omentum overlying the common duct, the latter is followed up until the cystic duct is exposed, when it is clamped with two long, narrow forceps and divided between the clamps with the cautery or scissors. The cystic artery is next exposed, clamped and cut. In the event of a long cystic and a long hepatic duct, the two joining just short of the duodenum, of the presence of an anomalous cystic artery, this dissection will expose them, and will also avoid injury to either the common or the hepatic duct. It will now be found that the gall-bladder can readily be peeled from its attachment to the liver.

Gangrenous cholecystitis is very rare because the gall-bladder has a rich blood supply through the cystic artery and the numerous vessels in its attachment to the liver. In acute cholecystitis the main blood-vessels in the wall of the gall-bladder may become thrombosed and gangrene may ensue. This condition, when it occurs, is usually an outcome of acute cholecystitis and requires similar treatment.

Acute perforation of the gall-bladder is unusual, because of the protection afforded by surrounding structures, and because bile tension within the gall-bladder is never high. The symptoms resemble those of perforated peptic ulcer and immediate operation is equally imperative. The wall of the normal gall-bladder is strong and capable of marked distention. When diseased the muscle fibres and connective tissue are invaded and weakened by inflammatory products. There is proliferation of the intramural glands and deepening of the crypts which honeycomb the wall. These changes predispose to slow perforation and permit the formation of surrounding adhesions with frequent attachment to the duodenum, stomach or colon. Finally a communicating fistula may form. Attachment of the gall-bladder to the duodenum is more often caused by cholecystitis than by duodenal ulcer. When the gall-bladder is found adherent to a neighboring viscus a careful search should always be made for a fistulous opening which may be very small. In case the fistula is large and patulous there is a strong probability of an obstructing stone in the common duct. The best procedure is when possible to remove the gall-bladder and close the fistula, and make a careful exploration of the common duct for stone.

Calculi are usually the result and sequel of cholecystitis. Perversion of cholesterin and fat metabolism may predispose to their formation. Modern opinion favors infection of the gall-bladder as the primary lesion. The cardinal symptoms of gall-stones and cholecystitis are often identical. Calculi may form early and are nearly always present in the late or advanced stages of cholecystitis. According to our conception of the pathology of cholecystitis, it is not reasonable to expect that inflammation and infection will disappear when only the stones are removed. Patients who have had chole-

cystostomy for stones may, and often do, continue to have persistent cholecystitis, although they may be temporarily relieved of symptoms, but more stones often reform. The cystic duct and the neck of the gall-bladder are usually involved in cholecystitis and are frequently obstructed. Permanent relief of symptoms by simple removal of the stones presupposes that the gall-bladder is capable of returning to its normal condition and that the cystic duct is patulous. But the former does not occur, and the latter is not always the case. In most instances nature has already extirpated the gall-bladder. The indications for cholecystostomy will be determined by the individual case and will depend on the necessities of risk, local pathology, and additional complications such as acute hepatitis, cholangeitis with stone in the common duct, and pancreatitis. In short, we believe that in cholecystitis, with or without stones, the gall-bladder should always be removed when conditions permit, unless it is to be used for biliary drainage, and even here drainage of the common duct is often more satisfactory. Retention of the gall-bladder for utilization in secondary operations on the biliary tract will be less indicated as the primary operation is made more complete and thorough.

The essential significance of jaundice is a disturbance of that part of the hepatic function which has to do with the elimination of bile pigment. In this respect the liver resembles the kidney in its relation to urea. Therefore jaundice may be functional or obstructive. The functional type may depend on the inability of the diseased liver to excrete its normal allotment of pigment, or in case the formation of pigment is excessively rapid the normal liver cannot adequately dispose of it. The latter condition probably prevails in hæmolytic jaundice. The liver probably modifies in some way the pigment brought to it. In the obstructive type of jaundice the block may be anywhere in the duct system either within or outside the liver. Intrahepatic obstruction may be the result of inflammation and œdema of the smaller ducts. Extrahepatic obstruction is caused by stone, stricture, carcinoma, and pancreatitis, and clinically is frequently complicated by infection. Obstruction of the common duct not only prevents the exit of bile, but also impairs the activity of the liver, so that in this condition functional and obstructive jaundice may be co-existant. Cholecystitis may be a cause of functional jaundice, but repeated attacks of colic and jaundice are usually caused by stone in the common duct. Within the past few years the mechanism and pathological significance of jaundice have been in large part explained and a method has been devised for measuring the pigment content of the blood. Bile pigment is formed in large part outside the liver and carried to it for excretion. Failure of excretion causes pigment to accumulate in the blood, and when the quantity rises above the threshold value of the kidney it appears in the urine, and later passes out of the blood-vessels into the tissues. Therefore, in biliary obstruction the degree of jaundice is dependent on variable factors, namely: the extent of the obstruction, the threshold value of the kidney, its capacity to excrete pigment and the permeability of the blood-vessels to pigment so that jaundice becomes an imperfect manifestation of increased pigment content of the

blood. The quantitative test for bile pigment in serum is particularly useful for following the progress of jaundice, and as a guide to the safest time for operation, but its interpretation must consider the above factors. The capacity of the kidney to eliminate pigment may explain the varying tolerance of patients for jaundice. The liver is the main site for urea formation and bile excretion; while the kidneys are the main exit for the former product and in obstructive jaundice they attempt to take over the latter function. Long-continued jaundice produces a toxic nephritis with an accumulation of urea as well as pigment in the serum. In jaundice there is a well-known tendency to bleed. In our experience this tendency cannot always be measured by the coagulation or clotting time of the blood and is not always directly proportional to the intensity of jaundice. We have noted that any tendency to bleed rapidly disappears when bile drainage is established. Surgical mortality in jaundice is probably more often the result of failure to establish bile flow with hepatic and renal insufficiency, than from actual loss of blood by oozing. The danger factors in obstructive jaundice are, pigment and bile salts in the blood, tendency to bleed, liver insufficiency and kidney insufficiency. To combat and control these factors should be our aim in the pre-operative preparation of the patient. It is our practice after careful study of the patient and employment of the recognized laboratory tests to build up the glycogen reserve of the body by the administration of glucose and insulin, to supply adequate fluid intake, and to fortify the blood by injections of calcium chloride and by blood transfusion. One must be cautious not unduly to prolong the period of preparation and pass over the opportune time for surgical intervention. Here the judgment and experience of the surgeon are the best guides. Cases of painless jaundice are the ones most suitable for study and preparation. When the symptoms such as pain, jaundice and intermittent fever indicate a stone in the common duct, there is little to be gained by the usual methods of preparation; prompt surgical treatment is the best procedure. Operations on jaundiced patients should be deliberate and thorough. The practiced surgeon will readily detect the basic pathologic lesion. The operation should be completed when possible in one sitting rather than divided into steps. Secondary operations on the biliary tract are not desirable neither from technical nor from therapeutic standpoints. To drain the gall-bladder or common duct and intentionally leave a stone for later removal is not for the best interests of the patient. In most instances the diseased gall-bladder and the stone in the common duct can be removed safely at the same time. After this procedure we drain the common duct with a T-tube. When obstruction is caused by disease of the pancreas and the gall-bladder is dilated and tense, internal drainage, cholecysto-duodenostomy, is the method of choice.

There is abundant clinical data to support the belief that pancreatitis is most often a sequel of cholecystitis; we believe that the usual pathway of infection is through the lymphatics. It is difficult to prove or disprove this by experiment; we must rely on pathological and clinical deductions and on the testing ground of experience at the operating table. We do not deny

that the pancreas may at times be the primary seat of infection or that disease may reach it by other channels than the lymphatics from the gall-bladder. A felon on the finger may be simply a local affair; it may involve the hand and arm through tendon and fascial planes; it may reach to regional lymph-nodes and cause painful swelling or suppuration; or within a few minutes it may blaze up the arm as a virulent lymphangitis. A similar relation may prevail between cholecystitis and pancreatitis from the mild and chronic to the suppurative and ultra-acute forms. Acute pancreatitis has clinical and pathological varieties which determine the type of treatment and the mortality. Some of the mildly acute forms, even in the presence of fat necrosis and free fluid, will subside with or without surgical intervention. Some of the suppurative types yield to simple incision and drainage when localization has been effected. Most of the ultra-acute cases speedily perish regardless of the course of treatment pursued. The clinical symptoms cannot always be relied upon to differentiate the types of the acute lesions. In the management of acute pancreatitis when the onset has been with agonizing epigastric pain accompanied by the signs of an abdominal catastrophy it is our practice to operate at once. The pancreas is exposed through the gastro-colic omentum and, if it presents no gross lesion, drainage is carried down to it. If there is an abscess or a hæmatoma the gland is incised with a blunt instrument and drainage provided for by gauze tampons surrounded by thick rubber dam and a rubber tube. In the subacute varieties immediate operation is not so imperative because a localized abscess often forms which can later be drained through the abdomen and sometimes by an extraperitoneal approach through the left loin.

The pancreas may be affected by chronic inflammation independent of disease of the biliary tract, but in the surgeon's experience chronic pancreatitis is most often a sequel of cholecystitis. The head of the gland, the part embraced by the curve of the duodenum, is the usual area of involvement. In spite of the intimate relation between this portion of the gland and the common duct, biliary obstruction rarely occurs when the pancreas is enlarged and soft. Drainage of the gall-bladder, except when the condition is very acute, will not have much effect upon the pancreas. Cholecystectomy by removing the focus of infection accomplishes the most good. When biliary obstruction is present, the head of the pancreas will usually be found enlarged and hard and often is indistinguishable from carcinoma. In these cases the pancreatic condition is probably not secondary to cholecystitis because in the absence of carcinoma cholecystoduodenostomy is usually followed by permanent relief of symptoms. Cholecystostomy may be made but biliary drainage will be protracted and has obvious disadvantages. We have seen a few cases of pancreatitis following cholecystectomy when a small stone has been overlooked in the terminal portion of the common duct.

Stone in the common duct is a complication of cholecystitis because all stones, with few exceptions, originate in the gall-bladder. The condition should be extremely rare after cholecystectomy unless a stone has been over-

looked at the original operation, which unfortunately may occur. In the removal of the gall-bladder which contains stones, it is important to be sure that small stones or sand are not allowed to remain behind in the stump of the cystic duct because of the danger of their ultimate entrance into the common duct where they may lodge. A similar sequence of events may occur in cholecystostomy when small stones in the cystic duct are very likely to be overlooked. The prevention of stones in the common duct in addition to the above precautions obviously consists in early removal of the diseased gall-bladder. From the clinical standpoint choledocholithiasis may be frank or obscure. The deception of the silent stone, so called, varies with the audition of the surgeon. The classical syndrome of colic, jaundice, and rigors is well known. Often one, sometimes two of this cardinal trinity, may be absent. Careful palpation of the common duct should be a routine procedure in all operations for cholecystitis. The features which cast suspicion upon the common duct are a history of jaundice following repeated attacks of colics, a contracted gall-bladder and a dilated thick-walled duct. It is not necessary to open and explore the duct in every suspicious case unless careful inspection and palpation throughout are prevented by the presence of exudate or adhesions. However, no doubt must remain in the mind of the surgeon. The principle of thoroughness is more important in this special field of surgery than in almost any other.

Stones in the supraduodenal portion of the common duct are easily removed. The duct may be grasped by forceps on each side and incised for about one-half inch; following a gush of bile the stone often pops into the wound. The duct should then be explored with the finger, if possible, with instruments which are made to pass into the duodenum. When the stone removed is facetted, look for more stones. Sand and putty-like material are best removed with a scoop. Flushing the duct is apt to carry stony debris into the intrahepatic ducts. When a stone is impacted in the ampulla or in the retroduodenal portion of the duct, it may be milked back, or if necessary, crushed and removed piece-meal. We rarely find it necessary or advisable to open the duodenum, although we sometimes mobilize it to expose the stone. Thoroughness is essential and the lumen of the duct must be cleared into the duodenum. We always drain the duct with a T-tube and when advisable remove the gall-bladder. The lower arm of the T-tube is purposely not allowed to enter the duodenum, because to do so accomplishes no good and may favor ascending infection. The T-tube is allowed to remain for at least three weeks, sometimes longer.

The advantages of pre-operative preparation of patients with jaundice caused by stone in the common duct are usually exceeded by the risks of delay after the diagnosis has been established. In the absence of cholangeitis and when subsidence of jaundice indicates relief of biliary obstruction, it is advisable to await the optimum improvement of conditions.

It is sometimes difficult to differentiate between biliary obstruction caused by stone and by carcinoma or stricture. However, calculus obstruction is

usually painful and incomplete, and the jaundice is variable and often accompanied by fever. In about twenty per cent. of cases of stone in the common duct jaundice is absent.

Hepatitis denotes inflammation of the parenchyma of the liver and has been shown to be most constantly associated with cholecystitis. In the acute form there is diffuse, dull aching pain over the liver, and sometimes fever and jaundice. The liver appears dull red and mottled, it is enlarged and the edge is rounded. In the chronic type the part of the liver adjacent to the gall-bladder is grayish-white, contracted and firm, the result of fibrous tissue. The present interest in hepatitis is chiefly from the standpoint of pathology and its relation to the etiology of cholecystitis. Little is known of its ultimate effects. Marked chronic hepatitis may exist with only slight changes in the gall-bladder and in advanced destructive cholecystitis the liver may be grossly normal. Present surgical opinion holds that when there is visual evidence of hepatitis the gall-bladder should be removed.

Varying degrees of cholangeitis are probably always associated with cholecystitis and with stone in the common duct. In acute or suppurative cholangeitis the surgical procedure should be the least possible consistent with immediate relief, which is best secured by biliary drainage.

Regarding the subject of biliary cirrhosis we are in accord with the principles so ably expressed and advanced by W. J. Mayo. The condition is usually a later complication or sequel of chronic cholecystitis and cholangeitis and often follows the intermittent biliary obstruction from a stone in the common duct. Cholecystectomy and removal of the obstruction may provide relief, but in well-established cases there is often persistent mild jaundice which sometimes clears up after splenectomy.

Cholecystitis affects the period of life when the attainment of physical maturity passes into the phase of depreciation; when the active processes of growth are being replaced by the struggling efforts of repair and maintenance. In the battle with infection several structures may fall together, or the fall of the one may weaken the defence of the other. The association of lesions, a league of lesions if you will, we speak of cholecystitis, peptic ulcer, and appendicitis, is actually so frequent as to be common surgical knowledge. Clinical experience leads us to believe that these gastro-enteric lesions follow in sequence from a primary focus of infection which is usually in the appendix. It would be of interest to compare the relative incidence of cholecystitis or ulcer in patients who have had their appendix removed with those who still retain it. It is our impression that many patients who are operated on for cholecystitis or ulcer subsequent to appendectomy had the above lesion prior to removal of the appendix. We advocate and practice, in all abdominal operations for chronic disease, examination of the gall-bladder, stomach and duodenum by sight and touch whenever possible, and we usually remove the appendix.

The causes of recurrence of symptoms following operation on the gall-bladder may be grouped as follows:

1. Incomplete primary operation, such as failure to remove the diseased gall-bladder, the appendix and a common duct stone, or to recognize and treat a peptic ulcer and chronic pancreatitis. Cholecystostomy may temporarily relieve the symptoms of, but does not cure a cholecystitis, and by its mechanical effects may be the cause of new symptoms. Likewise persistence of symptoms after gastro-enterostomy for ulcer may be caused by cholecystitis. Removal of the appendix, even when not acutely diseased, is a safeguard against future trouble.

2. Hepatitis and pancreatitis may persist for several months after cholecystectomy, and then subside. On several occasions we have drained the common duct in these cases with good results.

3. Accidents of the operation, of which injury to the hepatic or common duct is the most serious and unless promptly recognized and treated, may result in a stricture with jaundice or a complete biliary fistula.

4. Incorrect diagnosis both before and during operation. The surgeon must be trained in the art of diagnosis and in the recognition of pathological tissue.

ASSOCIATION OF CHOLECYSTITIS WITH DUODENAL ULCER*

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In the last one hundred operations for gall-bladder disease, I have met with five cases in which duodenal ulcer was also present although unsuspected either from the clinical examination or with the Röntgen-ray, and one case in which the two conditions were recognized as co-existing prior to operation. Although only a few isolated references can be found in the literature, most surgeons must have had a similar experience. Infection may reach the gall-bladder by direct extension through the duodenal papilla or by the lymphatics, in which case an ulcer of the duodenum is a possible starting point; or through the arterial circulation. It has been established that certain pathogenic organisms show a special affinity for some particular organ and tissue, and it is now believed that the blood stream is the principal route through which the gall-bladder is infected. Rosenow has shown that streptococci and colon bacilli from acute cholecystitis intravenously injected give rise to a like disease in animals. Is it not possible that these or other organisms may also cause ulceration of the duodenum? Healed duodenal ulcers have been found post-mortem in patients who gave no past history of digestive disturbance. In *Surgery, Gynæcology and Obstetrics* for January, 1924, the late Dr. Archibald Maclaren reports five cases in whom there was the co-existence of cholecystitis and duodenal ulcer. The late Dr. A. J. Ochsner stated in a clinical lecture that he had observed the two conditions associated in the same patient on several occasions.

It is now clear that we can no longer rely upon occult blood as indicating a gastro-intestinal lesion as this may occur in disease of the gall-bladder.

Dr. E. S. Judd in a paper read before the Southern Surgical Association in December, 1921, entitled—"Bleeding ulcer of the duodenum associated with cholecystitis" reports four patients upon whom he had operated for bleeding duodenal ulcers and in whom the pathological condition was more extensive in the gall-bladder than in the duodenum. In each case there was a very severe grade of cholecystitis with gall-stones. The chief symptom in each case was gastro-intestinal hemorrhage, usually very severe and occurring at intervals of a few months. All four patients complained of mild dyspepsia but none of them had severe pain and it was impossible to elicit a history of gall-stone colic or any other symptom suggestive of disease of the gall-bladder. In three cases there were small areas of duodenitis in the region of the duodenal cap with extensive hepatitis and cholecystitis with stones and infected bile. In one case hemorrhage occurred regularly every few days. At operation he was not able to find an ulcer but found cholecystitis with stones and extensive

* Read before the American Surgical Association, May 25, 1926.

TABLE I.

Case	Sex	Age	Duration of symptoms	Symptoms	Diagnosis	Operation	Result
M. S.	F	57	3 years	Biliary colic with jaundice. Pain 2 or 3 hrs. after meals. X-ray pos. for gall-stones, neg. for D. U.	D. U. with gall-stones	Gall-stones with small, hard pancreas and healed D. U. Obstructed appendix. Patient's condition not good enough to deal with D. U. Cholecystostomy. Appendectomy	Relieved.
A. R.	F	62	3 years	Nervousness and epigastric tenderness. X-ray neg. for gall-stones and D. U.	Gall-stones	Several small stones removed from gall-bladder. Scar of an old healed D. U. Appendix thickened and obstructed. Removed. Cholecystostomy. Appendectomy	Relieved.
M. A. P.	F	60	2½ years	Pain in epigastrum. Periodical attacks of vomiting. X-ray diag. Chr. stenosing D. U. No gall-stones	D. U.	D. U. Multiple small gall-stones. Gastro-enterostomy and removal of gall-stones	Cured.
E. B.	F	52	4 years	Tenderness over gall-bladder with biliary colic	Cholecystitis with gall-stones	Gall-stones and large D. U. Chronic appendicitis. Cholecystectomy and appendectomy	Relieved.
W. H.	M	65	5 years	Indigestion. Pain after eating. Vomiting due to retention	Cholecystitis D.U. with stenosis	Gastro-enterostomy	Cured.
E. A. H.	M	48	10 years	Pain 3 or 4 hours after eating, tarry stools. Last 4 months tender gall-bladder, 3 weeks jaundice	D. U. Cholecystitis. Cholangitis	Enlarged liver. Thickened gall-bladder. No stones. Head of pancreas hard. Healed D. U. Cholecystostomy	Died 3 mos. later from cholangitis.

scarring and œdema of the liver which oozed a great deal as the gall-bladder was removed. Several years ago Crispin in the Mayo Clinic studied a series of cases of gall-bladder disease and found a history of gastrointestinal bleeding in about 5 per cent. He says that in nearly every instance the bleeding ceased after the removal of the gall-bladder. Deaver reports profuse bleeding in hemorrhagic infections of the biliary tract. In one of his cases blood reached the duodenum through the common duct and then regurgitated to the stomach; the primary cause being streptococcic cholecystitis. Kelling in an article on the relation between cholelithiasis and ulcer of the duodenum, in speaking of the differential diagnosis between gall-bladder disease and ulcer of the duodenum, says, that occult blood with duodenal ulcer may mean nothing; it may also come from infections in the gall-bladder. Mix reports two cases of combined ulcer and cholecystitis, clinically diagnosed as such and confirmed at operation. The chief symptom in both cases was epigastric pain in one case coming on after food, in the other having no relation to eating. He based his reason for diagnosing gall-bladder trouble in both cases on foul breath, headaches, vomiting of bile, and the sensation of upward pressure experienced by both patients. There had been no attacks of biliary colic or jaundice. As Mix points out, the cardiac symptomatology is rare in ulcer and very common in gall-bladder disease, but the presence of a good deal of bile in the vomitus I do not think is uncommon in ulcer.

RECORD OF CASES

CASE I.—M. S., female, aged fifty-seven.

Chief Complaint.—Epigastric pain coming on about two hours after food. Had three attacks of severe pain in the right hypochondriac region which necessitated hypodermics of morphia. The last attack of this nature was followed by intense jaundice which lasted sixteen days. She had lost thirty pounds in weight in the last year and lived in dread of taking food. Past history: Severe pelvic infection at the birth of her last child eighteen years ago. Physical examination: The patient is well-developed but poorly nourished. Lower ribs prominent, skin very dry, sclera jaundiced. X-ray examinations on two separate occasions showed pressure on the duodenum between the second and third portions, the caput regular in outline. In spite of a negative X-ray examination for ulcer of the duodenum, a pre-operative diagnosis of ulcer was made, accompanied by cholecystitis with stones.

Operation.—The stomach was found to be small and thick-walled. There was an ulcer on the anterior surface of the duodenum one-half inch from the pylorus, three-quarters of an inch in diameter and containing new formed blood-vessels. Palpation revealed no stones in the gall-bladder, cystic or common duct. The gall-bladder was opened at the fundus, when the mucous membrane was found to be red, thickened and four small stones were removed. On account of the patient's poor condition, cholecystostomy only was done and the duodenal condition left for future operation if the symptoms necessitated it. Patient made a good recovery and is entirely relieved of the hunger pain and dread of eating, now three years since operation.

CASE II.—A. R., female, aged sixty-two. *Healed duodenal ulcer. Eight small faceted gall-stones. Chronic appendicitis.* Gave a history of stomach trouble and nervousness for a number of years. Two and one-half years previous to my seeing her she was examined by a consulting physician when the X-ray report was negative for duodenal ulcer and gall-stones. Gastric analysis was also negative. At this time she

complained of epigastric pain and was tender over the transverse colon. A diagnosis of colitis and psycho-neurosis was made. Just before seeing me another X-ray examination was made with a negative result for ulcer of the duodenum, but evidence of external pressure on the stomach from behind. She now complained of pain in the epigastrium and gas in the stomach and my diagnosis was gall-stones.

At the operation the scar of an old healed ulcer was found on the anterior surface of the duodenum one-half inch beyond the pylorus with an adhesion between the duodenum and the transverse colon and the edge of the liver, just external to the gall-bladder. Eight stones were removed from the gall-bladder and one from the common duct. The appendix was thickened and obstructed and was removed.

The patient made a good recovery. I have recently heard from her (two years after the operation), and she reports that she is enjoying good health with an absence of all her former symptoms.

CASE III.—M. A. P., female, aged sixty. *Obstructing duodenal ulcer with gall-stones.* For several years has had pain in the epigastrium with periodical attacks of vomiting of large quantities of fluid and partially digested food, and has steadily lost weight. Two years previous to my seeing her an X-ray examination was made with a diagnosis of stenosing duodenal ulcer and no gall-stones seen. Following the X-ray examination the patient was much improved, had less pain, less vomiting and gained in weight, over a period of one year and eight months. For the last four months she has had a recurrence of symptoms and was referred to me for operation. Diagnosis: Obstructing duodenal ulcer.

Operation.—An indurated ulcer was found on the anterior-superior surface of the duodenum, 3 c.c. by 2 c.c. with scarring and puckering. The stomach wall was two or three times its normal thickness and dilated to twice its normal size. A posterior gastro-enterostomy was done. The gall-bladder was found filled with multiple small stones which were removed.

The operation resulted in complete relief of her symptoms and she recently reported, three and one-half years since operation, that she has had no recurrence and has recovered her normal weight.

CASE IV.—E. B., female, aged fifty-two. *Cholecystitis with one large gall-stone. Duodenal ulcer. Appendicitis.* She had been ailing for several years. Four years ago she was seen by a consultant who diagnosed cholecystitis, chronic appendicitis and oral sepsis. She now complains of recurrence of her former symptoms, *viz.*, pain in the epigastrium, occurring at irregular intervals, nausea and belching of gas, no hunger pain and pain not relieved by eating. When I examined her there was tenderness and increased resistance over the appendix and gall-bladder regions. X-ray was negative for duodenal ulcer. Diagnosis: Cholecystitis and chronic appendicitis.

Operation.—The gall-bladder was found to be considerably thickened and contained one large stone. The appendix was chronically inflamed. A very large healed ulcer on the anterior-inferior aspect of the first portion of the duodenum was found but causing no stenosis. The gall-bladder and appendix were removed. As she had not had the usual symptoms of duodenal ulcer and as the ulcer appeared to be healed, and as her condition was not very good, it was thought best not to operate upon the stomach. It is now six months since the operation and last week her husband (a practicing physician) informed me that she had complete relief of her symptoms, had gained in weight and was feeling better than she had felt for years.

CASE V.—W. H., male, aged sixty-five. Had indigestion and attacks of pain in the epigastrium for ten years. Two years previous to my seeing him had a gall-bladder operation by another surgeon. A few months after this operation his symptoms recurred, with pain one or two hours after eating. For the last two or three months has had periodical attacks of pain with vomiting of large quantities of partially digested food. Has had gastric lavage twice a week for two months when retention was found of one to two quarts. Examination: Patient is greatly emaciated. The stomach is dilated,

occupying about one-half the abdomen. The passage of a stomach tube revealed about one and one-half pints of retention. Patient was given glucose interstitially and a stomach lavage every six hours for two or three days to prepare him for operation. Diagnosis now was duodenal ulcer, with stenosis.

At operation I found a huge duodenal ulcer on the anterior-superior surface of the first part of the duodenum just external to the pylorus, causing almost complete obstruction. The stomach was greatly dilated and thickened. Considering the evidence of long-standing disease in the duodenum, it seemes more than probable that the ulcer was present at the time of the former operation but was overlooked. A posterior gastro-enterostomy was done.

He made a good recovery and now, six months after operation, has gained twenty pounds in weight.

Case VI.—E. A. H., male, aged forty-eight. When the patient entered the hospital he had been ailing for three months and for the past three weeks had had marked jaundice, dark urine with recurring chills and an evening rise in temperature to 103–104 F. and pain in the hypochondriac region. On examination he was found to be very tender over the gall-bladder area and along the lower border of the liver, which extended about two inches below the costal margin. He gave a history of having had pain three or four hours after meals (relieved by taking food), and tarry stools, for the past ten years. Six years ago had what was called an exploratory laparotomy done when the gall-bladder and duodenum were examined and found normal, but a chronic appendix was removed. Diagnosis: Cholecystitis and cholangitis.

Operation.—The liver was found considerably enlarged, extending two inches below the costal margin. The gall-bladder was greatly thickened as also were the cystic and common ducts. The head of the pancreas was enlarged and very hard. The gall-bladder was opened when the wall was found to be infiltrated and the mucous membrane congested; no stones found. The duodenum was the seat of a thickened cicatrix of a healed ulcer in its first part just external to the pylorus. The gall-bladder was drained.

After an illness of about three months he succumbed to septic cholangitis.

CONCLUSIONS

(1) The co-existence of cholecystitis and duodenal ulcer is not rare and in operating for gall-bladder disease a careful examination of the duodenum should always be made.

(2) In this small series, although both conditions were present, the symptoms of gall-bladder disease predominated except in one case.

(3) In making a diagnosis the clinical examination is much more reliable than the X-ray.

(4) This series would seem to confirm my view that multiple operations in the abdomen, as too frequently practiced, are unwise and often unjustifiable.

BIBLIOGRAPHY

Crispin, E. L.: Toxic Gastric Hemorrhage. California State Jour. Med., 1917, vol. xv, pp. 308–312.

Deaver, J. B.: Gastric Hemorrhage. Surg., Gynec. and Obst., 1914, vol. xviii, pp. 294–299.

Kelling, G.: Die Beziehungen zwischen Cholelithiasis und Ulcus duodeni. Archiv f. Verdauungskr., 1921, vol. xxiii, pp. 63–68.

Mix, C. L.: Duodenal Ulcer Combined with Cholecystitis. Medical Clinics of North America, 1923, vol. vii, p. 337.

STRICTURES AND OPERATIVE INJURIES OF THE BILE DUCTS*

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Operative injuries to the bile ducts while not frequent are met with sufficiently often to make a study of the reason for their occurrence and the best method of repair of some interest. The reports in the literature are usually of one case or a limited series of cases, which are reported in order to demonstrate some method of repair. Considerable series of cases showing the end results of the various methods of repair have been seldom reported.

Cause of Injury.—The operative mortality and frequent necessity of reoperation, and the frequency of recurring symptoms, makes it worth while to consider the causes of injury and the method of avoidance. It is of interest that the accident has occurred at the hands of the best surgeons, sometimes in an easy case, and it may result either when the operation is started at the cystic duct and the cholecystectomy done from below upward, or from the fundus downward. But the accident has occurred here usually because of too much traction in the effort to remove the whole cystic duct, which it is better not to attempt as injury to the common hepatic duct is more likely to occur, than stones to form in the small amount of cystic duct remaining.

In the more difficult cases there may be:

1. Insufficient exposure, causing failure to recognize the cystic and hepatic ducts.

2. Traction on the gall-bladder, causing angulation, with clamping of a part or the whole hepatic duct.

3. Bleeding from an unseen point, resulting in a blind effort to clamp an invisible vessel, so that the duct is clamped, the clamp being left *in situ*, or the duct tied off around the clamp by means of a suture on a needle.

4. Inaccessibility of the duct may be due to a distended, inflamed and thickened gall-bladder, which causes marked shortening of the cystic duct.

Anatomy and Congenital Abnormalities.—In addition to these causes, in which the normal anatomy of the parts may be changed by pathological conditions, there are other conditions increasing the danger of injury, due to congenital, anatomical abnormalities. Eisendrath describes these abnormalities which may occur in the ducts and the vessels as follows:

1. The cystic duct does not always unite with the hepatic at an acute angle, as occurs in 75 per cent. of the cases. In 17 per cent., it may run parallel with the hepatic duct and its terminal, 2 cm. or more, may be united to the hepatic duct by fibrous tissue.

2. In 8 per cent., the cystic duct makes a twist in front of or behind the hepatic duct.

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* Read before the American Surgical Association, May 25, 1926.

3. More rarely, there may be accessory hepatic ducts which may empty into the common or cystic duct or into the gall-bladder. Or there may be a double common duct.

There are an equal number of possibilities of variations in the blood-vessels. The cystic artery may be double in 12 per cent. of the cases and does not always arise from the right hepatic. It may arise from the gastro-duodenal artery, a branch of which crosses in front of the common duct in 76 per cent. of the cases. The right hepatic artery lies behind the hepatic duct in 70 per cent. of the cases, and the cystic artery arises just beyond the right edge of the duct. But in 12 per cent. of the cases, the right hepatic artery passes in front of the right hepatic duct, and in 10 per cent. runs parallel to the cystic duct, close to the neck of the gall-bladder before entering the right lobe of the liver. In 8 per cent. of the cases, the right hepatic artery crosses the right edge of the main hepatic duct and then enters the liver, or forms a ring around the right hepatic duct.

While these anatomical abnormalities are to be kept in mind, the fact remains that the accident by far more frequency occurs in the absence of anatomical abnormalities, than as a result of this cause.

Site of Injury.—The location of the injury is frequently described as of the common duct, but, as a matter of fact, it usually occurs where the cystic and hepatic ducts join, or above this point. When the accident results from traction on the cystic duct, the resulting injury occurs at the point of union of the three ducts. When traction causes angulation, and the duct is cut, it is at the position where the cystic and hepatic ducts unite to form the common duct, or higher up in the hepatic. When a clamp is applied without proper visualization of the duct in an effort to stop bleeding, it is frequently on the hepatic duct itself. In many instances at operation it is found that the whole main hepatic duct up to the bifurcation in the transverse fissure of the liver is missing.

The point of union of the cystic, hepatic and common ducts is the narrowest part of the common duct, and the custom occasionally employed of draining the common duct by inserting a tube at the point of mergence of the cystic duct may result in subsequent stricture by ulceration, or destruction of the duct, a large portion of which may slough out in the presence of a severe infection with cholangitis. This occurred in one of my own cases (Case II).

Pathological Condition.—There may be a discharging sinus by which all the bile is discharged on the abdominal wall; or a patient with no sinus who is suffering from either a deep jaundice, when the obstruction is complete; or has a history of intermittent attacks of jaundice, pain and temperature elevation, due to a recurring cholangitis. The stricture may be only a narrow band (Case VII), or it may extend over a distance of 2 cm. or more (Case VIII).

At operation, the area beneath the liver in the region of the transverse fissure and about the common duct is occupied by a mass of adhesions. It

may be possible to find both ends of the duct. The lower portion may be found only with great difficulty in these adhesions, or may not be identified. In many cases the stump of the hepatic duct, or the right and left hepatic ducts may be retracted into the transverse fissure of the liver and appear as a small fluctuating area which can only be identified by aspiration of bile with a fine needle. In some cases, instead of forming a common pouch, they may be divided, each duct being closed off separately (Case I). Frequently a stricture remains patent, but very narrow, and it closes when cholangitis develops. Thick inspissated bile or sandy material, or even small stones may form behind, and cause blocking of the stricture (Cases VI and IX).

It is stated that in reconstructed ducts, epithelium forms rapidly to line the reconstructed area. While this has been proven experimentally on animals, it is still doubtful how much epithelium forms along the line of a reconstructed duct which has been repaired after an injury, particularly in the presence of cholangitis and infection. It would also appear to me that even if epithelium did form, as long as there has been any infection present, the surrounding scar tissue is going to contract and cause subsequent narrowing in many of these cases. In an autopsy protocol of one case reported in this article (Case VIII), in which the stricture extended for over 2 cm. there were isolated spots of epithelium, shown by the microscope, along the strictured area, but most of the strictured area contained no lining epithelium.

When the obstruction is almost complete, the liver is enlarged, with dilated intra-hepatic ducts often filled with thin, pale, watery bile. If the obstruction is relieved at operation, by opening the hepatic duct; or if the liver is cut into at autopsy, these dilated ducts collapse with a marked diminution in size of the liver. There is a varying amount of cirrhosis, apparently related to the amount and length of time the cholangitis has existed, and the liver may be hard and contracted, with a cirrhotic spleen and portal obstruction (Case VIII). Microscopical examination of the remaining duct shows round-cell and leucocyte infiltration as evidence of infection.

Symptoms.—When due to operative injury, the symptoms usually, but not always follow a post-operative history of prolonged drainage of bile from the wound. This drainage finally ceases, or a permanent fistula remains. When drainage ceases, the appearance of symptoms varies as to time. Occasionally, several years may elapse, then occur attacks of jaundice, pain, usually temperature elevation, and clay-colored stools. This may become progressively worse, or the patient may continue to have attacks of varying severity over months or years, finally requiring operation. The symptoms will vary also, depending on the degree of obstruction and amount of cholangitis, or the combination of both. It is sometimes difficult to reconcile the appearance of symptoms with the pathology found at operation (as in Case I). In this patient there was no biliary discharge following operation, the wound healed by primary union, and jaundice and signs of obstruction did not appear until four months later, although at operation the whole main

hepatic duct was missing up to the bifurcation in the transverse fissure of the liver, and the common duct was separated from this by almost 2 cm. It would appear that during this four-month interval there must have been some passage between the open divided ends which finally closed.

Methods of Repair.—There are many methods of repair suggested:

1. An end-to-end suture of the damaged duct, either with or without drainage, by means of the introduction of a T-tube; a tube through the ampulla of Vater; or with a tube leading through the stricture and coming out through the opening below in the common duct, and then led through the abdominal wall.

2. A division or excision of the stricture with the use of a tube in any of the previously mentioned methods.

3. Repair over a tube with an attempt to use the round ligament—the liver, the intestine, or the neighboring peritoneum, or the omentum to replace the missing portion of the duct.

4. Hepatico-duodenostomy, with the implantation of the remains of the cystic duct into the duodenum or stomach over a tube, more rarely into the jejunum or even into a segregated loop of small intestine (Kauch).

5. Hepatico-duodenostomy, with an attempt at partial reconstruction of the duct out of a flap made from the duodenal wall, or suture of the lower edge of an opening in the duodenum to part of the stump of the duct, the upper edge being sutured to the liver capsule (Mayo).

6. The implantation of the sinus into the duodenum or stomach.

In addition to these methods, cases have been reported of a lateral anastomosis of the duct to the duodenum. Cholecystenterostomy or cholecystgastrostomy has been done where the stricture has occurred and the gall-bladder has not been removed and is still functioning. Also the injury in the common or hepatic duct has in some instances been repaired by using a graft from the remains of the cystic duct (Kehr, also Judd), or the gall-bladder wall; and by telescoping the injured hepatic into the stump of the cystic (Walters). Cases are also reported of attempted repair by facial flaps, and such desperate measures when no duct could be found as, hepatostomy, cholangiostomy and hepato-enterostomy.

A choice of which of these operations should be employed, would necessarily depend in many instances upon the condition met with. But where such choice may be voluntary, it would be of assistance to determine, if possible, the end result of the various types of operation. An analysis of twelve cases from the Surgical Service of St. Luke's Hospital, together with a report of some of the other series of cases published, is the basis of this study. Many of these patients have had repeated operation. Several have been reported as cured or well, only to have a recurrence of their symptoms, sometimes after as long as two years of being symptom-free, and have died as a direct result of their condition, which would make questionable, the statement published in the ANNALS OF SURGERY in 1924, which says "patients who recover from the operation, usually have mild attacks of colic, with or

without jaundice, for several months or sometimes several years, and then completely recover."

Case I.—S. T., female, thirty-two. Cholecystectomy in another hospital, June, 1924. Had temperature following operation. Wound healed by primary union. Symptoms of jaundice and cholangitis in November, four months later. Bile index 167. At operation—December 30, 1924—stricture found at junction of hepatic ducts with a separation of between one and two cm. of stricture from upper end of normal duct below. Reconstruction by end-to-end suture over a T tube in December, 1924. Well five months and then had recurrence of symptoms which lasted until November, 1925. No symptoms since that time. Gained fifteen pounds in weight. Bile index at the present time nine. Now well eighteen months after operation, and symptom-free for six months. (Douglas.)

Case II.—D. H., female, fifty-four. Cholecystectomy in October, 1919. Gangrenous gall-bladder, stones in the common duct, cholangitis (bad infection). Part of duct sloughed out with drainage tube which had been sewed into wall of duct. Symptoms appeared August, 1920, eight month after operation—jaundice and cholangitis. Second operation, October, 1921, two years after previous operation. Closure of the ducts at bifurcation, which was connected with the common duct by a strand of tissue representing the posterior wall of the duct. Reconstruction by suture over T tube. Patient well one year, then symptoms recurred and persisted until May, 1923. Has been well since then (four years) and has gained seventy-three pounds in weight. (Douglas.)

Case III.—L. H., male, forty-six. Cholecystectomy in another hospital, June, 1919. Sinus never closed. Profuse bile drainage. Operation, December, 1919. Ducts found cut at junction of hepatic with common. Ends of cut ducts sutured together. Profuse drainage eleven days. Stopped on thirteenth day. Now well six years. (Downes.)

Case IV.—E. H., male, forty-four. Cholecystectomy in another hospital in 1917. Clamps left on for hemorrhage for forty-eight hours. Had attacks of jaundice for six months after operation, then well for three and a half years. Then for the next year had nine or ten attacks of pain, colic, and jaundice. At operation (June, 1922) a stricture was found at the hepatic bifurcation one-eighth of an inch in length which would not admit probe. Hepatics much dilated. Stricture cut, T tube inserted and left in one month. Two months later, recurrence of symptoms. Third operation in October, 1922. Recurrence of stricture which was again divided and T tube inserted. Well since (four years). (Downes.)

Case V.—J. V., female, twenty-two. Choelcystectomy in another hospital in August, 1919, followed by chills, fever and persistent sinus. Second operation in another hospital in November, 1919, for persistent sinus. This was unsuccessful. Operation in February, 1920. Stricture found in right hepatic duct which had been divided and retracted into liver. Left hepatic apparently continuous with common. No effort to suture duct at this operation. Fistula failed to heal and reoperation done August, 1920. Duct sutured over tube, led out through common duct above duodenum, and out through abdominal wall. Well six years. (Mathews.)

Case VI.—G. S., female, fifty-four. Cholecystectomy in another hospital in 1922. In hospital six months, then returned home, but had attacks of pain at times and continuous jaundice. Second operation for stone in common duct in 1923. In hospital six weeks. Was well eight months, then again had attacks of pain and almost continuous jaundice. Operation April, 1925. Patient jaundiced. Dilated hepatic duct found, opened and drained. Probe could be passed up to liver, but not down into common duct. Reoperation April 28, 1925. Sinus running down to dilated hepatic duct. Common duct not found in adhesions, Hepatico-duodenostomy over tube. Tube remained in place over two months and patient remained well until January, 1926 (nine months) when symptoms returned, and she was again operated on in February, 1926. At this time duodenum was opened—point of anastomosis of duct and duodenum dilated and inspissated bile and mucus escaped through opening. Tube inserted into duct and down into duodenum.

Duodenum closed. Wound healed and patient discharged three weeks later. Again returned to hospital six weeks later with some symptoms of jaundice and cholangitis, which cleared up in a few days. This was only two months ago—end-result cannot be stated. (Downes.)

CASE VII.—S. S., male, forty-two. (Case reported in ANNALS OF SURGERY, 1918, vol. lxvii, p. 619). Cholecystectomy in December, 1917. The hepatic duct was cut at its junction with the cystic. Immediate end-to-end suture done. Bile discharged six weeks and then stopped suddenly. Patient well to September, 1919 (twenty-eight months) then had attacks of pain with chills and some jaundice, all the time up to January, 1923, when he was again operated on. Stricture had recurred. This was divided and a T tube inserted. Tube continued to discharge bile and was left in for seven months. Stools showed bile, but eyes jaundiced at times. Biliary fistula persisted. Patient re-admitted to hospital, June, 1924, and died of mesenteric thrombosis. Autopsy showed fistula draining common duct. Hepaticus above stricture dilated and contains inspissated bile. Firm scar tissue band at centre of duct. The lumen is small but patent. Cirrhosis of liver. (Downes.)

CASE VIII.—L. H., female, forty-eight. Cholecystectomy in another hospital in 1916, followed one month later by jaunice. At operation, in same hospital, common duct not found, and hepatico-duodenostomy over tube was said to have been done with attempt to reconstruct lower end of duct from duodenum. Tube in place for several months. Since then intermittent attacks of pain, temperature and jaundice. Operation, September, 1917 in St. Luke's Hospital. Stone found impacted in ampulla of Vater, and removed transduodenally. Condition improved, most of bile entering duodenum, but had nausea, temperature and slight jaundice at times. Reoperation, November, 1917. Hepatic duct drained for cholangitis. Contained inspissated bile. Hepatico-duodenostomy not interferred with. The drainage ceased, and patient was in good health, gaining forty pounds, until June, 1919, when she again had chills, fever and jaundice when the duct at the hepatic fissure was again opened and drained. At this time there was bile in the duodenum, showing obstruction was not complete. Patient died in October, 1925, with ascites and deepening jaundice. Autopsy showed cirrhosis of liver, and large spleen. Ducts only moderately dilated. Beginning at the portal fissure there was an irregular strictured portion of duct at least an inch in length and about the calibre of a knitting needle. Below this, the duct appeared normal. It was the opinion of the operator, Doctor Mathews, that a hepatico-duodenostomy had not been done, as stated, at the previous operation, because of the continuity of the common duct, but that the anastomosis must have been made with the cystic instead of hepatic duct. (Mathews.)

CASE IX.—E. K., female, thirty-nine. Cholecystectomy in 1914. Part of common duct excised. Immediate suture and repair over a tube into duodenum. Permanent fistula developed. Six months later, reoperation, stricture one-half to three-quarters of an inch found. Stricture was excised and posterior wall sutured, but anterior wall could not be approximated. Defect covered anteriorly with round ligament and omentum. Patient well two and a half years, then reoperated on by another surgeon in October, 1916, who removed biliary calculi from above stricture and dilated latter. In January, 1917, symptoms recurred and operation done by third surgeon resulted in death of patient. (Lyle.)

CASE X.—O. O., female, twenty-nine. Cholecystectomy in another hospital in 1916. Drained five months—followed by fever, chills and jaundice. Operation in St. Luke's Hospital in May, 1918. Many adhesions, common duct not found. Many glands in region of ducts. Bile finally obtained from hepatic fissure of liver. Drained. Patient died after three transfusions. Autopsy showed hepatic ducts dilated to size of ring finger, completely closed off apparently from remains of common duct by adhesions and lymph-nodes, but probably some small lumen was present, as some bile had been present in stools during past year. (Mathews.)

CASE XI.—R. P., female, twenty-three. Cholecystectomy from below in November,

1924, followed by profuse biliary drainage. Patient was discharged one month after operation with wound healed and bile in stools, but returned in two months with jaundice. Was pregnant at time. Went through pregnancy. Had five or six attacks of pain, when jaundice would get worse. Operation, November, 1925. Common duct not found. Liver enlarged and contained several cystic masses. In portal fissure dilated hepatic duct found, containing white bile. Tube drainage of hepatic. Patient died five days later from hemorrhage, after three transfusions. (Downes.)

CASE XII.—V. S., female, forty-eight. Cholecystectomy for cholelithiasis, December, 1924. Bleeding following removal of gall-bladder stopped by clamp and suture ligature. Operation followed by biliary fistula and acholic stools. Refused reoperation. Reoperated on several months later abroad and died as result of operation. (Westerman.)

Analysis of these twelve cases from the Surgical Service of St. Luke's Hospital shows that five are well and symptom-free from one and a half to six years after operation (Cases I, II, III, IV and V) of these, two had second operations (Cases IV and V). All were cases of suture of the ducts. Three over a T tube (Cases I, II and IV). One with no tube drainage (Case III) well six years. One with tube led out through the common duct below the point of repair (Case V) well six years. Two had reappearance of symptoms after operation which lasted four to twelve months, but are now symptom-free eighteen months to four and a half years after operation (Cases I and II). One patient had a hepatico-duodenostomy and was well nine months. Recurrence due to narrowing of the lumen and obstruction from inspissated bile. Reoperation and return of symptoms two months later (Case VI). Too recent to give end-result.

One patient was well almost two years after immediate end-to-end suture, then reoperated, stricture cut and T tube inserted. Sinus never closed, symptoms occurred at intervals, and patient died one and a half years later of mesenteric thrombosis (Case VI). One died after four operations during eight years (Case VIII). One after repair over tube into duodenum, six months following immediate suture repair was well two and a half years, then had third operation, in another hospital, from which she died (Case IX). Two died of drainage operations, both of secondary hemorrhage (Cases X and XI). One of a repair in another hospital (Case XII).

It is obvious that no justifiable conclusions could be based on this series alone. Study of other series are of interest. Judd reports ten cases. Of these, four died (two as an immediate result of operation) one two years and one four months after hepatico-duodenostomy (Cases I, III, IV and V). Three cases were well and symptom-free. One in which stricture was divided and T tube used was well seven and a half years (Case II). One repair of defect by insertion of a piece of cystic duct, well seven and a half years (Case VI). One of transverse suture after spliting stricture and T tube used, well three and a half years after two years of symptoms (Case VII). Three cases still complained of some symptoms. Case VIII had three operations—division of stricture with T tube, a lateral anastomosis and a hepatico-duodenostomy. Was in good health for three years, but at times jaundiced. Case IX had two operations. In both the stricture was cut and a T tube

inserted. In good health for two years, but has had recurrence of pain. Case X had two operations, both hepatico-duodenostomies one year apart, and one and a half years later had attacks of pain and jaundice.

Seven cases of hepatico-duodenostomy are reported by Erdmann, which are classed as eight operations with seven patients. Two died (Cases III and V). Case I was well five years after second operation (hepatico-duodenostomy). Case IV, well five years after operation. Case VI had two operations and not reported cured. Case VII, tube in place eleven months—reported well three months later. Case VIII, reoperation five months after hepatico-duodenostomy and only reported as convalescent.

McArthur has reported five cases of repair of the ducts over a tube into the duodenum. The point of importance in these cases being the use of a cuffed tube or the funnel end of the tube which was placed in the duct above the stricture, a long portion of the tube going into the duodenum.

A personal communication recently received from Doctor McArthur gives the final report in these cases. Case I died two years after operation from carcinoma of the stomach. Case II died one and a half years after operation from septic cholangitis from the presence of a short tube that never passed, as described in his paper. Case III is still alive and free from jaundice eight years after operation, but every month or so has an attack of chills, fever and vomiting, suggesting intermittent cholangitis. Patient had a gastro-enterostomy five years ago for pyloric stenosis. Case IV still well. Case V operated on in 1913 by Doctor Finney, who found stone in the common duct which contained a fragment of rubber, probably from small portion of catheter. Believes patient is still alive.

In the series of fifty-one cases from the literature published by Eisendrath in 1920 and including cases of duct injury from the series of Eliot reported in 1918, there were fifty-one cases of injury to the bile ducts. Of these, the result after one year is only reported in four cases. The rest, in which any time is mentioned, are reported as well four to ten months after operation. The others are reported as dead as a result of operation, or recovered. One is reported as again having symptoms. There are five cases of operative injury with immediate transverse suture of the hepatic duct over a T tube, quoted from Kehr's Surgery of the Bile Passages, with the report, " all recovered and remained permanently well," but with no detail as to time mentioned. Of the cases reported as well over one year in this series, one by McArthur died two years later of carcinoma of the stomach; and one by Lyle (Case IX) died later as a result of operation for recurrence of symptoms.

Two cases in this series are of especial interest. One reported by Wolf in which the gall-bladder was anastomosed to the common duct, was reported well four years later; and one reported by Jenckel, in which there was an obliteration of the common and lower part of the hepatic ducts for a distance of 8 cm., which was repaired by means of a tube from the hepatic duct into the duodenum. The patient remained well four years after operation, and the operator states that four weeks after operation, when the tube was removed,

the canal, lined by epithelium, was found. Of the remaining cases, it is of interest to state that one case reported by Downes in 1918 as a case of recovery, died in 1924, having been reoperated with recurrence of symptoms; and also that the case in this series reported by Stettin, of immediate suture following the injury in 1915 was perfectly well at the time of the last report in 1923, nearly nine years after the operation. Two of the cases in the series are those reported by Erdmann, and the later results are found in his report, here abstracted. The literature contains many reports of isolated cases, in addition to this series, but as end-results are not given, they can add little to the information here sought.

Mention should be made of the method of treatment where a biliary sinus still persists by means of implantation of the sinus into the stomach or duodenum—this was unsuccessfully attempted by Von Stubenrauch in 1906. One of the first cases in which this was temporarily successful was by Murphy, who implanted the sinus into the common duct below the stricture, the patient dying eight months later with recurrence of symptoms. Several other attempts by this method have failed, but Lahey in 1924 reported three cases—one done two years previously and remaining well; the second patient died of carcinoma of the pancreas a few weeks later. In both of these, the sinus was anastomosed into the duodenum. The third case, in which the sinus was anastomosed into the stomach, had been done eleven months previous to the report, which stated that the patient was now well, but had twice had attacks of jaundice, accompanied by chills. Lilienthal has also reported on a similar operation done in December, 1921, in which the fistula was dissected out and implanted in the stomach near the pylorus, and a report from her family physician states that she has been perfectly well since then—four years later. St. John, at a recent meeting of the New York Surgical Society, presented a case in which similar operation was done, the patient being symptom-free twenty-one months after operation. If this method is employed the sinus should not be dissected down below the margin of the liver, to the lower surface of which it is usually attached, because of danger of injury to the sinus wall in attempting its separation.

Examination of the end-results of the series of twelve cases followed at St. Luke's Hospital, together with the reports of the other series of cases, makes any definite conclusion as to the best method of repair difficult if not impossible. Certain conditions limit the choice of operation, such as the location of the injury—the amount of destruction of the ducts—difficulty in approximating the divided ends—the amount and density of the adhesions—the presence or absence of a sinus—the condition of the patient, such as the degree of jaundice, the amount of impaired liver function, or actual destruction of, or change in the liver tissue. It has been stated by previous writers on the subject that the two main factors of recurrence of symptoms are, cicatricial contraction, and ascending infection, causing cholangitis. In various methods of repair by means of hepatico-duodenostomy, or implantation of a sinus, attention has been called to the absence of the sphincter of Oddi

as the cause of this ascending infection, but in the St. Luke's series of cases, in which suture of the duct was done, cholangitis, as shown by jaundice, chills and fever, was not of infrequent later occurrence (Cases I and II). It would appear from the St. Luke's cases, as well as those of Judd's, that the cases of direct repair without a tube or with a T tube were the ones that gave the best end-results in the largest number of cases, although several of these had recurrences and required reoperation; while those in which a repair was done and a deficiency left for some other tissue to bridge over the gap, in many instances had recurrence of symptoms. Sullivan's case, however, was reported well four years after operation. Successful bridging over a long gap is not impossible, as shown by the cases of Jenckel, Kehr and Riggs, who were able to mobilize the ends of the duct and perform an end-to-end suture after a separation of 2 to 3 cm. The patient of Riggs being reported well four and a half years later.

Immediate recovery, as shown by McArthur's series, is usual in the cases of tube reconstruction. The end-result over a long period of any number of similar cases can not be determined from the data collected. The same statement must be made as to the results of hepatico-duodenostomy. One patient on which this was done in the St. Luke's series has required subsequent operation and has had recurrence of symptoms since then. Of the Erdmann series, only two were reported well for a period of five years. Of Judd's series, two cases had attacks of jaundice at times after hepatico-duodenostomy. There are, however, several cases in the series collected in the excellent article by Eliot on Repair of the Hepatic and Common Bile Duct, published in 1918, and not included in Eisendrath's report, which show a successful result of implantation operations for a period of years—one of Dujarier's well three years and one of O'Day's well six years after implantation of the duct into the stomach. And successful cases of hepatico-duodenostomy well seven years reported by Summers, four years by Bazy, four years by Mann, three years by Crile, and fifteen months by Wilms, are included in this collection of cases; also the case of W. J. Mayo of implantation by his method well more than fifteen years.

Reoperation or autopsy on patients who have had recurrence of symptoms or died after their operation, shows that frequently there is a canal which remains patent, although this canal is usually markedly narrow in calibre, and that the attacks of cholangitis and jaundice are due to the obstruction caused by inspissated bile or the formation of small stones, or detritus behind the point of obstruction. In two of the cases of the St. Luke's series (Cases I and II) this occurred after operation, and after a period of from four to nine months in each case, with the administration of large doses of bile salts, these symptoms cleared up and the patients have remained well since—one a year and a half after operation and one almost four years. Whether this was due to the medication or not, cannot be definitely stated. It is not, however, illogical to suppose that the condition which favored the formation of

stones, for which the original cholecystectomy resulting in the duct injury was done, may persist, and be favored by a partial obstruction or stasis in the duct. Therefore, anything which would help to keep the cholesterin in solution and favor the increased flow of bile may be of benefit, if symptoms of partial obstruction or cholangitis appear.

If any conclusions can be arrived at from the data studied, it would appear, that when possible to immobilize and approximate the ends of the ducts, direct suture is the method of choice, although here too, occur some recurrences. Perhaps the more favorable results are partly due to the lesser amount as well as of density of adhesions that makes this procedure possible. If a tube is used in this operation, it seems of importance not to choose one that has too large a calibre, as pressure may cause necrosis of destruction of the epithelial lining of the duct. If direct union cannot be accomplished, hepatico-duodenostomy, either over a tube or by the direct method of Mayo, when the duct is very short and the duodenum can be mobilized, seems to be the second choice. While the method of reconstruction of the duct over a tube becomes a last resort when other methods are impossible. Occasionally, methods of repair of a defect by means of a portion of remaining cystic duct or implantation of the remains of a cystic duct into the hepatic may be employed, but the opportunity to use such a method would only be in the occasional case. The same circumstances apply to the implantation of a persistant sinus. If the patient is deeply jaundiced and in poor condition, and mechanical conditions make further operation hazardous, it is frequently advisable to drain the hepatic duct above the obstruction, and defer the repair operation.

Whatever operation is done, there is a considerable percentage of recurrence. In a certain number of cases there may be a return of symptoms, either of obstruction or cholangitis or both, for a number of months or years which then clear up and the patient remains well. Many patients, however, in whom these symptoms intermittently recur will become worse and require reoperation. Others may remain well for months or even years and then have all the evidence of a recurring stricture.

SUMMARY

Injuries to the bile ducts may occur in a simple operation or be due to pathological conditions rendering the operation difficult, or to congenital abnormalities of the ducts or arteries. Traction on the cystic duct, lack of visualization or blind attempts to stop hemorrhage are the most common causes.

2. The site of the injury is usually at the point of union of the cystic and hepatic ducts, or the main hepatic duct above this point, less commonly of the common duct.

3. The symptoms are those of biliary obstruction, with or without cholangitis, usually intermittent in character, the obstruction later becoming permanent. More rarely a persistent biliary fistula is present.

4. The pathological condition present may show a narrow calibre stricture which is very short to 2 cm. or more in length, above which small stones,

mucus or biliary detritus is often found. The ducts above the stricture are dilated and the liver enlarged and soft, or may be cirrhotic when attacks of cholangitis have persisted.

5. Methods of repair are numerous and must depend on the condition found. Recurrence of symptoms are reported after all methods. Examination of follow-up reports appear to indicate that the best end-results follow suture of the ducts when possible. The next most favorable results where a number of cases are reported follow hepatico-duodenostomy.

6. Recurrence of symptoms may occur after the patient has been apparently well for months or years, or symptoms may disappear after several months of recurrence.

7. In two cases reported, the disappearance of late symptoms seemed to be influenced by the administration of bile salts.

8. Report of twelve cases from the Surgical Service of St. Luke's Hospital of New York is given.

BIBLIOGRAPHY

Crile: Quoted by Eliot.
Downes: ANNALS OF SURGERY, 1918, vol. lxvii, p. 619.
Dujarier and Bazy: Bull. et mem. de Chir., No. 36, p. 1318.
Eliot: Surg., Gyn. Obstetrics, 1918, vol. xxii, p. 81.
Eisendrath: Surg., Gyn. and Obstetrics, 1920, vol. xxxi, p. 1.
Erdman: Amer. Journal Surgery, May, 1924.
Jenckel: Deutsche Ztschr. f. Chir., vol. civ, p. 40.
Judd: ANNALS OF SURGERY, 1924, vol. lxxx, p. 210.
Kauch: Arch. F. Chir., 1908, p. 50.
Kehr: Surgery of the Bile Ducts, vol. i, p. 135, 1913.
Lahey: Clinics of N. A., December, 1924, p. 1483.
Lilienthal: ANNALS OF SURGERY, 1923, vol. lxxvii, p. 765, Personal Communication.
Lyle: Quoted by Eliot.
Mann: Surg., Gyn. and Obstetrics, 1914, vol. xviii, p. 326.
McArthur: ANNALS OF SURGERY, and Personal Communication, 1923, vol. lxxvii, p. 129.
Murphy: Quoted by Eliot.
O'Day: Quoted by Eliot.
Riggs: Quoted by Eliot.
St. John: Reported before N. Y. Surg. Society, April, 1926. Not yet Published.
Stettin: N. Y. Med. Record, 1915, vol. xcviii, p. 630.
von Stubenrauch: Chir. Congress, 1906, vol. ii, p. 39.
Walters: ANNALS OF SURGERY, 1924, vol. lxxix, p. 78.
Wilms and Brandt: Ztschr. f. Chir., vol. cix.
Wolf: Zentralbl f. Chir., 1914, vol. xli, p. 231.

STRICTURE OF THE COMMON BILE DUCT*

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Secondary operations on the biliary tract are among the most difficult tasks in surgery. The difficulty depends not only on the technical problems, but also on the presence of biliary cirrhosis and cholangitis. Stricture of the common duct always results in jaundice, either constant or intermittent. It is usually operated on as a secondary operation, although the belief is becoming more prevalent, through accumulated experience, that in a considerable proportion of cases common duct stricture is the result of a general obliterative cholangitis.

Considering these cases from the standpoint of management and treatment, they naturally fall into three groups: (1) Those in which the stricture is due to obliterative cholangitis; (2) those in which trauma at a former operation resulted in a complete biliary fistula, and (3) those in which the stricture also results from operative trauma but, on account of the closure of the ducts, is associated with complete and persistent jaundice.

OBLITERATIVE CHOLANGITIS

In reviewing the records of our cases of stricture of the common duct, sixty-four in all, I have been greatly impressed by the fact that in a goodly proportion the common duct had been patent for many months, and in some instances for several years, after the cholecystectomy and before any sign of stricture developed. It is difficult to attribute these late manifestations to anything that took place at the time of the cholecystectomy. From some of the case records it is also found that there was clinical evidence of intermittent obstruction of the duct before any operation was performed. No cause could be found for this when the gall-bladder was removed, but in the absence of a stone, it must mean that cholangitis was present prior to any operation. In certain other cases the signs of obstruction of the common duct have occurred soon after the gall-bladder operation; at the time of the secondary operation, instead of the expected stone in the common duct, an obliterative process was found extending throughout the course of the duct. Diffuse cholangitis is difficult to recognize because the inflammation in the walls of the ducts produces a great amount of œdema in the duct and all the surrounding tissues, and the duct itself lies concealed in a hardened inflammatory mass. The disease for which the gall-bladder was removed is a part of the same obliterative process which extends through the liver and ducts.

Stricture of the common duct is frequently spoken of as congenital and acquired. It was formerly thought that the congenital type was the more frequent. Moynihan said that congenital stricture of the common duct is a

* Read before the American Surgical Association, May 24–26, 1926.

part of the disease which has been described as congenital obliteration of the bile ducts. He thinks it is probable that, as Ralston has suggested, the disease is primarily instituted during fetal life by poisons derived from the mother and conveyed to the liver of the fetus, and that a combination of cirrhosis and cholangitis is set up. The result is an obliterative cicatrization of the ducts. This would seem to explain the truly congenital stricture found in infants shortly after birth and the absence of a demonstrable common duct at operation. It seems to me that this same process could be started in an adult by certain conditions independent of any inheritance. The literature has recorded many cases which have occurred between the ages of nineteen and sixty. Usually these are given as single case reports, but all of them are similar in the clinical symptoms and findings. The stenosis comes on insidiously and is accompanied by the usual signs of stone in the common duct. There is usually a complete remission between attacks. Frequently a number of small stones are found in the ducts, but these are probably the result of the stenosis and not the cause of the general obliterative process. A stone wedged tightly in the common duct might produce an ulcer the healing of which would result in stenosis, but it is not likely that it could be the cause of a general obliterative process in the intrahepatic ducts as well. In my experience the occurrence of stricture following the passage or removal of stones from the common duct has been very infrequent.

Stricture has followed severance of the duct during the performance of cholecystectomy, and undoubtedly some of those that are seen are due to this mishap. I am of the opinion that an obliterative inflammatory process throughout the ducts is the real cause of many of the strictures attributed to trauma. In sixteen of the series of sixty-four cases in which operation was performed for stricture, the condition was the result of obliterative cholangitis, and in fifteen more the etiologic factor may have been cholangitis. When the stricture is of this origin, the obstruction is usually not complete and, as the structures are separated from the surface of the liver and finally the common duct is opened, there is not the rush of bile or white fluid that is observed in the cases of traumatic stricture. The duct appears as a rounded opening on the surface of the liver and no amount of dissecting will isolate a common or hepatic duct. These are the most difficult cases of all to handle. The best that can be done is to make an opening in the duodenum and make a side-to-side anastomosis over a tube to the remnant of duct wall in the liver. The immediate results are usually fairly satisfactory but in many of these cases the trouble recurs. It is not a good plan to advise another operation at the first sign of difficulty as some of these patients will have slight attacks of chills and jaundice intermittently for a time and then become entirely well. In the event that the difficulty persists, further operation should be considered, as some of the most complicated conditions may finally be relieved, apparently as the result of subsidence of the obliterative inflammatory process. If the condition is not relieved, however, increasing biliary cirrhosis and destruction of hepatic tissue are sure to ensue.

CASE I.—A woman entered the clinic in November, 1912, at which time cholecystectomy was performed for chronic cholecystitis which had been causing symptoms for one year. She was relieved of all of her symptoms for two years following the operation and then experienced vague and indefinite pain in the epigastrium which lasted for five days. After this attack she was free from symptoms for two years. At this time she began to have severe attacks of colic, usually accompanied by jaundice, and at the end of a year an exploratory operation was deemed advisable. A stricture was found at the juncture of the cystic and common ducts, incised, and the duct reconstructed over a T-tube. Bile drained for seventeen days. The patient convalesced promptly. According to a report five years after the second operation the patient is perfectly well and neither the pain nor the jaundice has recurred.

Comment.—The stricture in this case was localized, but it did not occur until four years after the gall-bladder was removed. I believe that the best explanation is that the stricture was a part of an obliterative cholangitis.

CASE II.—A woman, aged sixty-six, first entered the clinic in December, 1911, at which time she gave a twenty-year history of epigastric pain, radiating posteriorly and to the right shoulder, and of indigestion and qualitative food distress. During the immediate past few months she had suffered from pain sufficiently severe to require morphin for relief, the attacks occasionally being accompanied by jaundice. At the first operation in December, 1911, partial cholecystectomy (three-fourths) had been performed and a stone removed from the common duct. A Robson drain was used. The gall-bladder was empyematous and filled with stones. Bile drained for about two weeks, but after that the wound healed promptly and the patient remained well and free from symptoms for thirteen years. She returned to the clinic in 1922 because of myocarditis, rheumatic endocarditis and aortic insufficiency with acute decompensation. After medical treatment in the hospital for three weeks she recovered sufficiently to warrant her return home. She had no complaint that could in any way be attributed to the biliary system.

Four years later she again returned to the clinic, this time because of severe attacks of pain in the right upper quadrant of the abdomen, radiating posteriorly and requiring morphin for relief. Each attack was accompanied by nausea, vomiting and jaundice, but there had been no chills nor fever. She had had four attacks in two years. The heart showed some fibrillation and decomposition. However, the history pointed to abdominal pain of such severity that further operative treatment seemed advisable, and on February 11, 1926, an exploratory operation was performed. There was a small stump of gall-bladder remaining. The common duct was constricted at the juncture of the cystic and hepatic ducts. This stricture was incised, and the duct reconstructed over a Robson hepaticus drain. Some bile drained for about two weeks and then the wound closed. The immediate convalescence was satisfactory, and at the last report a month ago the patient stated that she was completely cured.

Comment.—In this case the common duct had been patent and the patient free from all symptoms referable to the biliary system for thirteen years after the partial cholecystectomy and removal of the stone from the common duct. Whether a stricture occurring after that length of time was due to the ulceration where the stone formerly lay, or whether it was due to an independent inflammatory process, is difficult to decide, but it would seem that it would be just as likely to be due to the latter as the former. In the few other cases in which a stricture has formed after a stone has passed or has been removed from the duct, it is possible that the stricture resulted from cholangitis.

CASE III.—A married woman, aged forty-one years, first came to the clinic in 1920, complaining of intermittent chills, fever, and jaundice since cholecystectomy had been performed in 1919. Her mother had died of cancer; no other family tendencies were elicited. The patient had been pregnant twice.

A few months following the cholecystectomy in 1919 all of her symptoms had returned; the common duct had been explored but no calculi were found. A tube inserted into the common duct drained bile for several months. After the tube was taken out, pain, chills and fever returned. The patient was jaundiced at the time of examination in 1920. I performed hepaticoduodenostomy, using a large rubber tube. After this the patient did very nicely for four years, then had an attack of sharp pain in the right upper quadrant, with chills, fever and jaundice, which subsided only to recur at intervals, although soreness in the right upper quadrant had been constant since the first attack.

In January, 1926, five years after hepaticoduodenostomy was performed, the patient returned to the clinic. The hæmoglobin was 49 per cent.; the erythrocytes numbered 3,190,000, and the coagulation time was seven minutes. The serum bilirubin was estimated at 2.5 mg. for each 100 c.c. of blood. The hepatic function test showed dye retention 2. The röntgenogram showed the tube in good position in the duct.

February 3, 1926, I removed the tube from the intestinal tract. March 1, the patient was dismissed, apparently in good condition. The jaundice had entirely cleared up, and the wound was well healed.

Comment.—This case illustrates two points: First, it seems to show that we are justified in continuing to operate if the trouble recurs; and second, that this woman was entirely free from symptoms for the four years that the tube was in place. One stitch had been used to hold the tube to the duct structures, but other than this nothing was done to keep it in place. After four years of relief she began to have symptoms of cholangitis and slight infection. It seemed best to remove the tube because it might be the source of this trouble. When it was removed it was thickly coated with bile pigment. A small nick was made in the intestine, the tube withdrawn and the opening closed. There was some evidence of cholangitis for a time after this and it was three weeks before the jaundice had entirely disappeared.

STRICTURE OF THE COMMON DUCT WITH BILIARY FISTULA

The cases of stricture in which there has been a biliary sinus and no jaundice are the more favorable for operation. Biliary cirrhosis and jaundice are not present. The chief difficulty lies in the handling of the duct which has not become dilated. It is well to keep in mind that in these cases, in spite of the biliary drainage and the lack of clinical signs of jaundice, there may nevertheless be a certain amount of biliary cirrhosis and latent jaundice, and careful estimates of the serum bilirubin should be made to determine the necessity for preparatory treatment before an operation is undertaken. In cases of biliary fistula, the fistula, after dissection, can be used as a duct, and anastomosed to the duodenum, as has been done by Murphy, Lahey, and others. Stricture does sometimes ensue, and it is often better to excise the fistula and anastomose the common or hepatic duct to the duodenum. Anastomosis of the stump of the common duct to the side of the duodenum has given the best results in my experience in all cases of stricture of the common duct. Sometimes it seems best to perform a plastic operation at the site of

the stricture or an excision and an end-to-end anastomosis. If there is any trouble in locating the distal end of the duct, as there often is when the duct is completely severed, it is preferable to disregard it.

STRICTURE OF THE COMMON DUCT WITH IMMEDIATE AND COMPLETE RETENTION OF BILE

In case the duct has been severed and the proximal end closed, jaundice will immediately ensue, and will gradually increase without pain, chills or fever. The content of serum bilirubin rises very rapidly. No bile is found in the duodenum or fæces. The jaundice becomes very deep yellow and then changes to green. These patients require the most careful attention before anything can be done, and in spite of all precautions the risk of operation is very high. The longer the time since the jaundice became complete the greater will be the risk. The amount of bilirubin in the blood serum is the best index to the degree of the risk and no operation should be undertaken during the time the serum bilirubin is increasing. After prolonged preparation by increasing elimination, repeated intravenous administration of calcium, and an occasional transfusion, certain of the cases of complete obstruction can be carried through an operation. Although calcium chlorid tends to increase the amount of serum bilirubin at first, its general effect is to decrease it. If nothing is done to relieve the situation, it is surprising how long some of these patients continue to live under these conditions. Operating on this type of case is certain to be accompanied by a great amount of oozing as the adhesions are separated. These oozing surfaces should be controlled by ligature and suture rather than by gauze packs which invite a recurrence of the bleeding when they are removed. Transfusion should be given as soon as the operation is completed, even though it does not seem necessary at the time.

The technical steps in the operation can be carried out in a much more satisfactory manner by making the separation of the adhesions close to the surface of the liver. If the suspensory ligament can be identified and the liver supported by traction on the ligament, it is possible sometimes to brush the adhesions away from the surface of the liver, and in this way expose the region of the severed duct without opening into the general peritoneal cavity. This is a great advantage when it can be accomplished and less reaction will follow this form of operation than that in which it is necessary to pack off the peritoneal cavity. As the surface of the liver is exposed and the region of the duct approached, a rounded projection which is tense and full of fluid is found where the hepatic duct formerly was. When this is opened, clear or white fluid gushes out as if it had been held under considerable tension. This fluid is the secretion from the glands in the wall of the duct and generally, as soon as it has escaped, bile-stained fluid appears. Anastomosis of this stump of duct to the duodenum is the best course to pursue. It is often impossible to tell which duct one is dealing with, and while it would be well to know whether it is the right or left hepatic or the common duct, still it is not

essential. If one hepatic duct is intact and is anastomosed to the duodenum, that is sufficient. Damaged hepatic tissue regenerates very quickly, and if a large part of the liver is destroyed or removed, rapid compensatory hypertrophy occurs in the remaining portion.

The following case is one in which a complete stricture was found which seemed to be the result of trauma at the time of cholecystectomy:

CASE IV.—A woman came to the clinic December 3, 1925. Cholecystectomy had been performed in March, 1925, for cholecystitis with stones. She had suffered from typical attacks of gall-stone colic for three years previous to the operation, but jaundice had been invariably absent. At the time the gall-bladder was removed the surgeon stated that he had explored the common duct without opening it and found it to be normal. The wound was drained. Three days after the operation the patient began to show some signs of jaundice. After a few days the wound opened and discharged a little bile. It opened and closed several times during the next eight weeks and finally remained closed. As soon as bile stopped draining to the outside, jaundice increased, pruritis appeared, the stools were clay-colored, and the urine was dark. The patient had no pain during this time. Duodenal tubing indicated that a small amount of bile was passing through the duct, although jaundice was very deep. The serum bilirubin ranged from 8 to 12 mg. for each 100 c.c. of blood.

About the middle of December, more than nine months after the cholecystectomy, and after considerable pre-operative preparation (jaundice was very deep), an exploratory operation was performed. It revealed a stricture of the hepatic duct just below the surface of the liver. In this case the common duct was very readily exposed, so I opened it about 2.5 cm. below the surface of the liver, passed a large probe up into the hepatic duct and obtained a considerable quantity of bile. I dilated the stricture and put in a T-tube, one limb of which extended well up into the intrahepatic duct. This seemed simpler than hepaticoduodenostomy, although if the trouble recurs after the tube is removed, it may be necessary to anastomose the hepatic duct to the duodenum. This tube is to be left in from six to eight months.

Comment.—This case illustrates those in which the symptoms come on immediately following cholecystectomy and persist until the secondary operation. It was impossible to ascertain at the time of this second operation just what might have occurred at the first one. In some cases the duct is undoubtedly severed, in others it may be clamped and ligated, while in still others it is possible that the reduction of the circulation to the tissues and the reaction in the tissues following the use of a considerable amount of drainage material might be factors in producing these strictures. Traumatic strictures will undoubtedly occur occasionally in spite of all precautions, and one method of removing the gall-bladder may be just as good as another. In order to avoid accident, one rule must always be followed, and that is, never to clamp or cut what appears to be the cystic duct until it has been completely separated from all of the surrounding structures.

CONCLUSIONS

1. Obliterative cholangitis resulting in stenosis of the common or hepatic duct is the cause of a considerable proportion of strictures of the common duct that have been classified as traumatic. These cases can often be recognized before the first operation. The symptoms are generally intermittent. Repeated operation is indicated if necessary.

2. Stricture of the common duct in which a biliary fistula exists may be deceptive in that there may be unexpected biliary cirrhosis. Careful study and any indicated preparatory treatment should be followed out in spite of the lack of jaundice.

3. Complete jaundice and severe biliary cirrhosis accompany the severance of the duct when the proximal end is closed. It is necessary to spend a great deal of time in preparing the patient for operation. It is also necessary to give much attention to the post-operative care.

4. Anastomosis of the stump of the common duct or the opening in the surface of the liver to an opening in the duodenum over a tube is the most satisfactory operation.

5. In certain cases recurrence of symptoms follows operation for stricture of the common duct. If these symptoms persist and increase, further operation is indicated and with some prospects of permanent relief.

THE OPERATIVE MANAGEMENT OF COMMON DUCT STONES*

By George W. Crile, M.D.
of Cleveland, Ohio

Operations upon the common duct still are formidable and still carry much of their old risk. Stones in the common duct may be removed by a perfect technic by a perfect surgeon, but the patient dies. The mortality of operations upon the common duct is as high as that of operations for the removal of tumor of the brain. Because of the similar high mortality in these two groups of cases, I propose to offer evidence which tends to show that the disturbance of either of these two great organs by an operative procedure affects the organism in a similar manner. After operations upon either of these organs there is a rapid loss of bodily energy; consciousness fades slowly, and in each case there is little, if any, medication which can influence the unfavorable course of the patient. In each the state of the blood-pressure and the circulation give but little clue to the gravity of the condition. The brain and the liver are alike highly sensitive to variations in temperature. Each is a powerful organ manifesting variations within it in a peculiarly dramatic way; each is absolutely essential to life.

In the case of the brain, through the development of an exquisitely protective technic, as is emphasized in the practice of Cushing, the forbiddingly high mortality of operations by the untrained hands of the general surgeon has been strikingly reduced. Are there corresponding possibilities in surgery which impinges upon the liver? It has been noted elsewhere that both the brain and the liver are master organs whose functions are the result of chemical activity and therefore are fundamentally affected by temperature variations. Each of these organs responds as a whole to every activity of the organism. Therefore, as one would expect, each has an extensive development of nerve extension. Each is sensitive to any disturbance of its nerve connections. In view of this fact it is strange to note that this primary essential to the maintenance of the optimum function of the liver has been little regarded, if at all, in the literature pertaining to this subject. This is perhaps due to the fact that interference with the nerve supply of this gland is not met by such immediately obvious and dramatic response as that which follows interference with nerve connections in the brain or the recurrent nerves, for example, in the course of a thyroidectomy. Let us, therefore, consider briefly the effect of temperature changes and of crude interference with the sympathetic nerves and ganglia of operations upon the common duct.

Sympathetic Nerves and Ganglia.—Within the field of operations upon the common duct lies what might be termed the "brain" of the sympathetic nervous system—an exquisitely sensitive structure which is the centre of a tangled network of extremely sensitive sympathetic nerves which supply the

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organs whose function is essential to life, among them the liver. As has been shown in particular by Macallum and by Berkley every individual liver cell has its own complete nerve supply. Moreover, a network of fibres from the sympathetic nerves and from the left vagus nerve surrounds every blood-vessel and capillary and every duct within the liver. By means of this extensive nerve supply the liver is as completely coördinated with the organism as a whole as is the brain. Because of the interrelations with the other viscera through the sympathetic ganglia, from which the principal nerve supply of the liver is derived, in operations upon the common duct the surgeon may greatly interfere not only with the innervation of the liver, but with the innervation of the pancreas, of the adrenal glands, of the stomach, of the intestines; indeed, every part supplied by the sympathetic nervous system may be affected. Obviously, in the course of a vigorously aggressive operation upon the common duct the surgeon is doing to the abdominal brain what would correspond to the effect of a digital search with an illogical, stupid finger throughout the real brain. Thus a crude search for a common duct stone would correspond with a crude search for a tumor in the brain. This line of reasoning is pertinent only if it can be proved that any mechanical disturbance of the sympathetic ganglia, of the fibres of the sympathetic nerves, or of the vagus do produce a gross disturbance of bodily function, in extreme cases leading to death. In support of this reasoning, therefore, the following facts may be presented: (1) The clinical effects of a breaking up of dense adhesions in the course of a search for the common duct causes a general bodily effect comparable to that produced by manipulation of the spinal cord or of the brain. (2) Experimental trauma of the sympathetic nervous system—interference with the sympathetic nerve supply—produces cytologic changes in the liver cells as well as in brain cells. (3) Strong emotional stimuli causes cytologic changes in the cells of the liver. (4) Blocking the splanchnic nerve supply greatly reduces the systemic effects of manipulation of the viscera.

The point to be emphasized is that not only is the function of the liver interfered with by rough manipulation of the common duct region, but that the effect is body wide. Clinical experience and experimental researches make it clear that because of the above considerations, operations upon the common duct require a wide regional block with novocain and, when feasible, a splanchnic block; a clear exposure; a sharp feather edge dissection, as has been so clearly demonstrated by Deaver; and a bloodless field, a suction apparatus being used to pick up bile or any oozing of blood. Such a technic meets the factor of nerve injury in common duct operations extremely well. The details of the technic for searching for a stone in the common duct need hardly be repeated here.

Up to the present point we have been considering only such injury as may be inflicted during the performance of the operation itself. Nerve injury may be produced, however, after the operation by drainage. There is no excuse excepting absolute necessity for the introduction of a drain of

any kind into the field of the sympathetic ganglia and sympathetic nerve fibres when a better drain can be placed in the right flank terminating in Morrison's pouch.

Another factor of danger is the drainage of the common duct itself. Sudden decompression of bile in a jaundiced patient may have the same effect on liver function as the sudden decompression of urine in the case of obstruction of the urinary system. The normally closed biliary system maintains adequate bile pressure within the system, therefore instead of draining the common duct I close it just as I would close incised intestines. The function of the bile with its high alkalinity, when its pressure is maintained at a normal degree, is to maintain the alkalinity of the liver cells. Drainage of the common duct under any circumstances reduces this pressure to zero; and if there is a sudden release after a high back pressure due to obstruction the effect is the same as that produced by the sudden breaking of a dam—*i.e.*, the pressure is temporarily reduced far below the normal level. It should be borne in mind also in connection with the question of drainage that faulty drainage may produce a well instead of a stream. Too much fluid may accumulate before it escapes, with immediate resultant functional disturbance and the more remote result of adhesions, which in turn interfere with liver function and consequently with general organic function. This damage is met or largely eliminated by employing gravity drainage through Morrison's pouch. Owing to the position of this pouch the accumulation of fluids will be avoided and the resultant adhesions will not be at such vulnerable points as those encountered by an anterior drain. When this method of drainage is employed the primary abdominal incision can be closed at once. When the common duct is thus closed and the drain is inserted laterally in Morrison's pouch, as there is no drainage in the common duct there will be less scar tissue and fewer adhesions in this vulnerable field, and both the immediate postoperative convalescence and the clinical end results will be by so much the more improved.

By the technic thus described the operation is carried along with minimum anæsthesia, with minimum disturbance of the sympathetic nervous system and, in consequence, with minimum disturbance of the vital organs. But another factor remains to be considered. Since the liver is the greatest chemical factory in the body; since it furnishes one-third of the heat of the body; since the liver is essential to life and its activity balances with that of the brain; and since the activities of these two organs depend on chemical activity, and chemical activity is influenced by temperature, the relation of the temperature of the liver to operations which impinge upon it remains to be considered.

By experimental researches in the biophysical laboratories of the Cleveland Clinic it has been found that the introduction of heat within the abdomen causes an immediate rise, not only in the temperature of the liver, but also in the temperature of the brain, the rise in the temperature of the brain occurring synchronously with the change in the temperature of the liver. It would follow from this observation that the application of heat to the liver

should in large part counteract the effect of operations upon the liver and bile ducts. As a result of our interpretation of this experimental fact we have been applying heat to the liver by means of diathermy which we have found to be an ideal method of holding the temperature of the liver at a normal level. One plate of the diathermy apparatus is placed on the lower chest on one side and the other is brought opposite the dome of the liver. The current can thus be continually applied during the operation and the temperature of the liver and the abdominal viscera can be maintained at or above the normal throughout the operation regardless of the exposure of the intestines; moreover, the application of the diathermy current during the immediate post-operative hours is of great aid in carrying the patient through that critical period.

In our present series of cases of common duct stones—still small—which have been managed according to the plan described above, our results have been strikingly in contrast with the results of operations before this plan was adopted. Under this plan the mortality and morbidity attending operations upon the common duct should show a like change to that which has followed the present plan of management of operations upon the brain and of operations for hyperthyroidism.

HYDROPS OF THE GALL-BLADDER IN AN INFANT*

By Henry Milch, M.D.
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Disease of the biliary tract has been considered as belonging essentially to adult life. Until quite recently the observation of isolated cases in children and young adults was thought a matter of great rarity and worthy of special notice in the literature. In 1913, Khautz [6] was able to discover only fifteen instances occurring in patients under the age of seventeen. Somewhat later Albú [1] described a large number of cases which he designated enterogenous cholecystitis and cholangitis occurring in children. He called attention to the marked increase in the morbidity of these infections and attributed it to the poor state of nutrition of the children during the war. About four years ago, I saw a five-year-old girl operated on for "appendicitis"; instead of the appendix, an acutely inflamed gall-bladder was removed. In an adult, the diagnosis of cholecystitis would undoubtedly have been suggested by the location of the maximum point of tenderness well above the umbilicus; but in this child, and probably in many similar unreported cases, her age seemed to preclude the likelihood of this condition.

While there appears to have been an increase in the number of infections, the recorded instances of other biliary tract diseases in children are still almost negligible. It does not appear that tumors have been seen. Carey,[2] Paterson and Wyllie [9] and Still [11] collected a total of only twenty-six cases of gall-stone formation in children under the age of twenty. Hydrops of the gall-bladder is yet among the greatest of rarities. In a series of 131 cases of gall-stone disease, Villard [12] reported only two cases of hydrops in patients under the age of twenty. De Haen [5] is reputed to have seen, at autopsy, a two-year-old infant in whom calculi obstructing the cystic duct were the cause of the hydrops. Charron [3] reported having seen a large hydrops in a child just recovering from typhoid fever. In 1909, Montenbruck [8] saw a five-year-old boy who developed a huge mass in the right hypochondrium ten days after the onset of scarlet fever. At operation, this was found to be an acute hydrops of the gall-bladder from which 250 c.c. of bile was aspirated. No stone was discovered and the ducts appeared to be free for the passage of a sound. After cholecystectomy, the child made an uneventful recovery.

The following case appears to be noteworthy because it is probably the youngest in which the diagnosis was clinically established before operation:

Lucille R., sixteen months old, was admitted to the medical service (Doctor Huber) on July 13, 1925, with a history of having contracted a "cold" three days previously. Until the onset of her present illness, the child had been apparently normal in every respect. Before her entrance into the hospital, the child had a slight rise in temperature,

* From the service of Dr. Walter M. Brickner, Broad Street Hospital.

a light cough and a mild diarrhœa. The stools were yellow, very offensive in odor and contained a moderate amount of mucus. On admission, the temperature was 104° F., pulse 150, respirations 70, and the child looked very sick. The eyes had a fixed stare but no signs of meningitis were elicited. There was a slight roughening of the breath sounds at the right base posteriorly but no definite pneumonic consolidation was found. The abdomen was slightly distended but soft and no masses could be palpated. Expectant treatment was instituted. The child continued, however, to have unexplained temperatures from 101° to 105° F. On the 17th, a large, tense, fluctuating mass moving

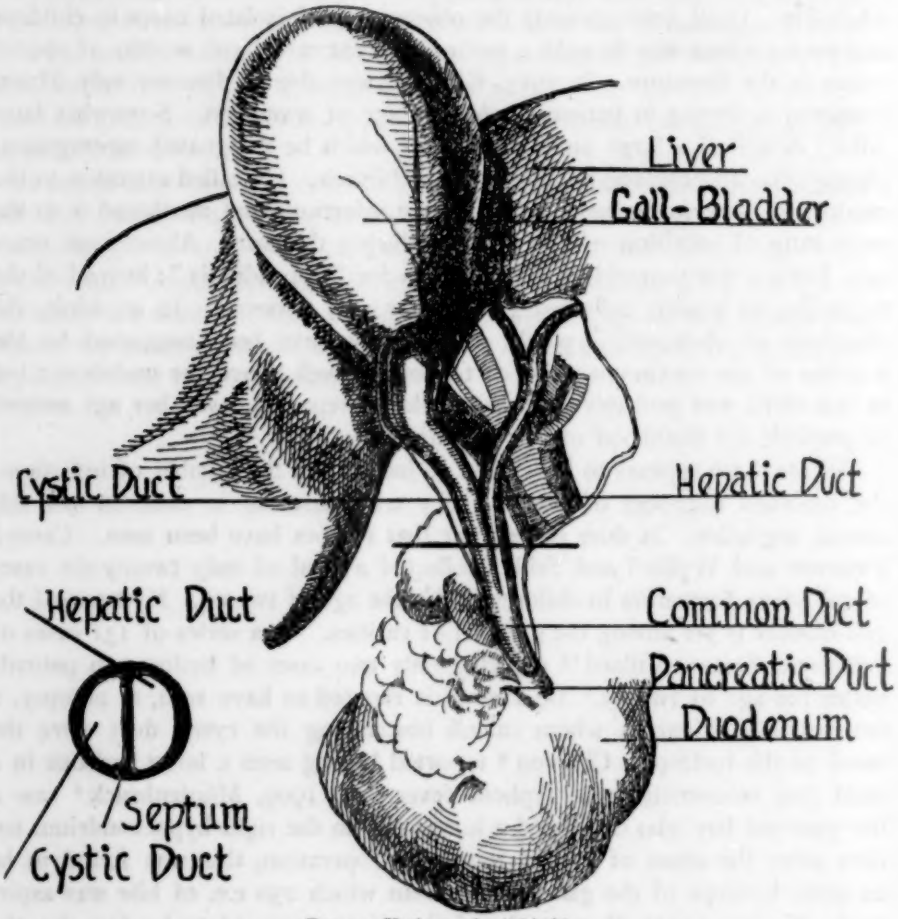

FIG. 1.—Hydrops of gall-bladder.

with respiration and apparently attached to the liver was discovered. A differential blood count showed 3,490,000 red blood-cells; 17,500 white cells with 64 per cent. of polymorphonuclear leucocytes; 49 per cent. hæmoglobin with a color index of .620. Polychromatophilia, basophilic strippling, microcystosis, anisocytosis and poikilocytosis were seen on the stained smear. The spinal fluid examination performed on the following day showed three cells per c.c., normal albumin and globulin and a colloidal gold curve of 0111000000.

The abdomen became progressively more distended. A positive Kernig sign, rigidity of the neck and tetany of the hands developed. The girl appeared to have become blind. The pupils were dilated and did not react to light or accommodation. The diar-

rhœa continued, food was refused and the child had to be nourished by gavage. Shortly thereafter she began to vomit and the surgical service was called into consultation. It was felt that some at least of the intestinal symptoms might be due to the enlarged gall-bladder and it was decided that the condition of the patient warranted an exploratory laparotomy. On the 23rd, Doctor Brickner operated, found an enormous hydrops of the gall-bladder and performed a rapid cholecystostomy. As the viscid, colorless bile escaped and the thinned-out walls collapsed, a few drops of green bile welled up from the neck of the gall-bladder. (This bile was cultured and after forty-eight hours was reported to have remained sterile.) Because of the condition of the patient, the common duct was not sounded; but palpation revealed no stone—nor indeed was any to be expected.

For a few days following operation, there was a slight biliary discharge on the dressings and the condition of the child was thought to be slightly better though it was now recognized that she was suffering from an encephalitis. This apparent improvement was only transitory. The spasticity of the neck and extremities became more marked and an external strabismus developed. On the 31st the wound broke open. On August 14th a gradual enlargement of the head suggesting an internal hydrocephalus was noted and on the 25th the child died.

Complete autopsy was not permitted and only the abdominal contents could be examined through the laparotomy wound. The peritoneum appeared normal. There was no dilatation of the stomach nor any evidence of obstruction anywhere along the gastro-intestinal tract. The liver was normal. The gall-bladder remnants were found shrunken against the liver. The bile ducts were of normal diameter and could all be easily injected with fluid and probed with a sound from the papilla of Vater upward. No obstruction of any sort was found nor could any calculi be detected in any of the ducts even in the liver. The right and left hepatic ducts measured about 2 cm., the common hepatic about 1½ cm., the cystic duct 1 cm. and the common bile duct about 3 cm. On dissecting the duct system, the muosa appeared to be normal in color and texture. It was noticed, however, that the cystic joined the hepatic duct at a very acute angle. Their lumina were separated by a thin septum which projected downward from their angle of fusion and which was gradually lost in the course of the duct. (See illustration.)

It may seem fruitless to speculate on the actual modus operandi in the present case. No calculi were found, nor was there any evidence of kinking or congenital obstruction along the biliary tract. Still, two facts stand out as of interest and possibly of significance in attempting to explain the condition. These are the conformation of the cystic duct and the appearance of the hydrops shortly after the onset of an acute infection. It seems hardly necessary to enter upon a discussion of the various anomalies of cystic and hepatic duct junction. Ruge, in a study of 43 gall-bladders showed that in 32 per cent. of the cases the cystic joined the hepatic duct at an acute angle and that in 20 per cent. of the cases it ran parallel to it before fusing. In this case, the cystic duct joined the hepatic at a very acute angle and seemed thereby to give rise to a rather elongated angle of fusion which I have referred to as a septum. This septum-like projection of the fused walls into the common duct and the oblique course of the cystic duct may have exercised some faint sort of sphincter action against the flow of bile. It may be that, with the addition of the factor of gastro-intestinal infection, the inflammatory œdema may have become of just sufficient degree to completely occlude the cystic passage and thus lead to the development of the hydrops.

This suggestion is advanced not as something proven but merely to supply a hypothetical basis on which the hypothetical sequence of events may be reconstructed.

Had there been a complete autopsy in this case, it might have been possible to explain on an anatomic basis the symptoms and the course of the disease from which this patient died. Without that, the outstanding point of interest was the condition of the gall-bladder. A great many etiologic factors in the production of hydrops have been described by different authors. All agree that a stone in the cystic duct is by far the most usual cause. Other mechanisms have been recorded, however. Quincke [10] noted that it might be due to "kinks" in the ducts, adhesions of the gall-bladder to the neighboring organs or inflammatory swelling of the mucous membrane of the cystic duct. Langenbuch [7] observed that it might arise as a result of traction downward by the colon, or by congenital atresia of the cystic duct. Courvoisier [4] reported a case of hydrops due to intussusception of the cystic duct while Villard [12] suggested that, in some cases at least, inspissation of the bile might account for the cystic duct occlusion.

It is quite probable that as the number of cases observed among young individuals increases, some or all of these various mechanisms, so common among adults, will be recorded. Diseases of the gall-bladder and, indeed, of the whole biliary apparatus seem to be either increasing or becoming more readily diagnosed. It may not be too fantastic to suggest that a goodly percentage of the vague gastro-intestinal disturbances of childhood, and adolescence may be evidences of biliary dysfunction.

REFERENCES

[1] Albú, A.: Med. Klin., March 18, 1920, p. 286; also June, 1918.
[2] Carey, J. D.: Jour. A. M. A., vol. lxxxvi, April 17, 1926, p. 1209.
[3] Charron: Quoted by Langenbuch.
[4] Courvoisier: Quoted by Langenbuch.
[5] De Haen: Ratio Medendi, Part 4, p. 132. Quoted by Villard.
[6] Khautz, A.: Zentralbl. f. die Grenzgbte. der Med. u. Chir., vol. xvi, 1913, p. 545.
[7] Langenbuch, C.: Deutsch. Chir., 1897, Lief. 45 C. Teil 2, p. 180, *et seq.*
[8] Montenbruck: Deutsch. Med. Wchnschr., 1909, No. 24, p. 1065.
[9] Paterson and Wyllie: Amer. Jour. Dis. Chil., vol. xxix, April, 1925, p. 516.
[10] Quincke, H.: In Nothnagel's System of Medicine, 1889, vol. xviii, p. 172.
[11] Still: Quoted by Carey.
[12] Villard, René: Thèse de Paris, 1910.

MORTALITY FOLLOWING OPERATIONS ON THE BILIARY TRACT, PANCREAS AND LIVER*

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There were 1182 operations on the biliary tract, pancreas and liver performed at the Mayo Clinic during the year 1924. This number includes sixty-seven operations for carcinoma of the gall-bladder or ducts, and operations for pancreatic or hepatic diseases which will be considered separately. There were 1115 operations on the gall-bladder and bile ducts alone. This group consisted of thirty-six operations for acute cholecystitis and 861 operations for chronic cholecystitis with or without stones, seventy-six operations for cholecystitis and associated diseases, and 142 operations on the bile ducts alone.

These operations were all performed under standard hospital conditions by the same permanent-staff surgeons. Many of the patients had been confined to the hospital for pre-operative observation and preparation. Probably the greatest single factor in lowering the mortality rate in the cases attended by great surgical risk has been the careful supervision of the pre-operative treatment. This is especially true in cases of jaundice in which the risk is extremely grave; in many of them, however, there is little hope for relief except by operative measures. Almost as important is the correct post-operative management. The operative technic has been more or less standardized by the individual surgeons. Perhaps the greatest change in method has been the minimal use of drains in the uncomplicated cases of disease of the gall-bladder. In these cases, if the operative field is dry and there is no local infection, laparotomy wounds are closed without drains of any kind; this seems to result in fewer and milder post-operative reactions.

On account of the diversity of pathologic findings in the biliary tract and associated diseases found at operation, which must be considered in the mortality rate, it is very difficult to classify the operations uniformly and draw any definite lesson from the information made available at necropsy. Therefore, it seems expedient, for the sake of simplicity, to classify these operations on the basis of both the primary and secondary lesions.

ACUTE AND CHRONIC CHOLECYSTITIS

There were thirty-six operations performed for acute cholecystitis with or without stones with death in two cases, and 861 operations for chronic cholecystitis with or without stones with death in fourteen cases, a total of

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TABLE I

Mortality Following Operations for Cholecystitis, 1924

Acute cholecystitis, with or without stones	Operations	Hospital mortality Cases	Per cent.
Cholecystectomy	25	..	..
Cholecystostomy	10	2	..
Cholecystectomy and choledochostomy	1	..	..
	36	2	5.5
Chronic cholecystitis, with or without stones			
Cholecystectomy	820	12	1.4
Cholecystostomy and partial cholecystectomy	2	..	..
Cholecystostomy	39	2	5.1
	861	14	1.6

897 cases with death in sixteen cases (1.7 per cent.) (Table I). In this group of operations performed for both acute and chronic cholecystitis, cholecystostomy was performed in forty-nine cases with death in four (7.2 per cent.). In these four cases the surgical risk was considered grave, but in view of the conditions present, operative procedures were justifiable, if not demanded by the necessity for some relief. Furthermore, the operative findings were such that the minimal amount of surgical procedure was indicated, and cholecystostomy was performed more for the relief of acute conditions than for a permanent cure. In one case the blood urea rose to 376 mg. with evidence

TABLE II

Analysis of Death Following Cholecystostomy for Acute and Chronic Cholecystitis

Case	Age, years	Duration of symptoms	Days lived after operation	Cause of death	Associated conditions.
1	54	5 months	15	Acute nephritis. (No necropsy)	Acute pancreatitis, grade 3; gallstones.
2	73	5 years	13	Hemorrhage, intestinal and intraperitoneal	Multiple duodenal ulcers; biliary cirrhosis 3.
3	50	4 years	23	Hypostatic pneumonia. Multiple abscesses of the liver	Chronic cholangeitis; cholecystitis, and choledocholithiasis.
4	57	5 weeks	1	Generalized fat-necrosis	Cholelithiasis; pancreatitis 3, with abscess; perforating gastric ulcer; multiple perforating duodenal ulcers.

of nephritis, the cause apparently being acute nephritis with uræmia. In the second case death followed intestinal and intraperitoneal hemorrhages which were not arrested by repeated transfusions of blood or intravenous administrations of calcium chlorid. In the third case death followed multiple abscesses of the liver which were probably caused by the same focus of

infection as was responsible for the pancreatitis and cholangeitis. In the last case the condition was obviously extremely bad at the time of operation and, as is usually seen in this type of case, the pancreatic abscesses and general fat necrosis eventually caused death (Table II).

Case I.—The patient, aged fifty-four, was a large, well-nourished man, with a slight degree of jaundice. At operation, many adhesions were found around the gall-bladder which was completely buried in omentum. The pancreas was very large and showed acute inflammation. The gall-bladder was opened and the stones were removed. Because of the acute condition it did not seem advisable to do more at that time. Cholecystostomy was performed and two Penrose drains were inserted down to the head of the pancreas.

The tenth day after operation the patient became irrational and the blood urea rose to 376 mg. The patient failed rapidly and died from acute nephritis on the fifteenth day after operation. Necropsy was not permitted.

Case II.—A man, aged seventy-three, was in very poor general condition and was jaundiced at the time of examination. At operation four days after admission, a very marked degree of hepatitis was found and a small contracted gall-bladder which was buried in dense scar tissue. A large stone could be felt, but it was difficult to say whether it was in the gall-bladder or in the common duct. It was removed and cholecystostomy was performed. Considerable bleeding was controlled by a gauze pack and three clamps. The eleventh day after operation the patient had a severe gastro-intestinal hemorrhage from which he never fully recovered, and he died the thirteenth day after operation.

Necropsy revealed multiple duodenal ulcers with intestinal hemorrhage, intraperitoneal hemorrhage, and a marked degree of biliary cirrhosis. The gall-bladder had been completely destroyed.

Case III.—A man, aged fifty, came to the clinic because of jaundice. He was very ill and, while a diagnosis of cholecystitis was made, operation was considered with some hesitancy because of his poor general condition, although an attempt at relief seemed imperative.

At operation, two weeks after admission, the gall-bladder was found buried in dense adhesions and contained septic material. The common duct was carefully examined. While no stones could be felt in the gall-bladder or common duct, their absence could not be definitely determined. The pancreas showed a moderate degree of acute inflammation. Cholecystostomy was performed and drainage provided by rubber tubes and gauze. The patient remained very ill after operation; had several chills and almost constant nausea. There was very good drainage of bile. He became comatose and died twenty-three days after operation.

Necropsy revealed chronic cholangeitis and cholecystitis with choledocholithiasis and multiple abscesses of the liver, pancreatitis and hypostatic œdema and congestion of the lungs.

Case IV.—A woman, aged fifty-seven, had been confined to bed because of severe epigastric pain, hæmatemesis and melena for five weeks prior to her admission. The hæmoglobin was 42 per cent. and there was no free hydrochloric acid in the stomach. The report of the röntgenogram of the stomach was carcinoma. The patient was given a transfusion of blood.

At operation very extensive adhesions were found throughout the abdomen and there was evidence of fat-necrosis on the omentum. The stomach was adherent to the anterior abdominal wall and to the liver. The gall-bladder contained stones and there was marked pancreatitis. The stones were removed and the gall-bladder was drained. A lesion of the stomach could not be demonstrated. Because of the acute condition, further exploration was not made. A blood transfusion was given immediately after the operation. The patient died the following day.

Necropsy revealed multiple perforating gastric and duodenal ulcers, chronic pancreatitis with abscesses and generalized fat-necrosis.

Cholecystectomy was performed in 845 cases. Three other operations were performed, two of which are classified as partial cholecystectomy and cholecystostomy, and one as choledochostomy with cholecystectomy. As recovery took place in these three cases and they therefore have only a negligible effect on the mortality rate, they will not be included in the total number of cases in which cholecystectomy was performed for simple acute and chronic cholecystitis. Death occurred in twelve cases in this series (1.4 per cent.) (Table I). It will be noticed that the mortality was greater following cholecystectomy performed for chronic cholecystitis than for acute cholecystitis. The first impression is that this should not be the case, but the total of twenty-five cases in the group of acute disease can scarcely be fairly compared with the total of 820 cases in the group of chronic disease. Whereas there were no deaths in the former group, the death rate in the latter was 1.4 per cent. On studying the mortality in these cases, one finds that death could not usually be attributed directly to the actual operative procedure or conditions present in the biliary tract. This seems of some importance, especially as in this group jaundice was not an important feature and surgical risk was not considered grave.

DETAILED ANALYSIS OF CAUSES OF DEATH FOLLOWING CHOLECYSTECTOMY (TABLE III)

CASE V.—A man, aged fifty-five, came to the clinic, March 5, 1924, because of abdominal pain. He was well-developed and weighed 182 pounds. Röntgenograms of the stomach indicated duodenal ulcer. However, on account of the history, a diagnosis of cholecystitis with stones and duodenal ulcer was made.

TABLE III

Analysis of Causes of Death Following Cholecystectomy in 845 Cases

Case	Age, years	Duration of symptoms	Days lived after operation	Additional operation	Cause of death	Associated disease.
1	55	2 years	0	Appendectomy	Unknown (cardiac disease?)	
2	52	7.5 years	2		Cardiac disease	Obesity (205 pounds).
3	56	30 years	3		Cardiac disease	Obesity (200 pounds).
4	59	3 years	6		Peritonitis	
5	53	2 years	4		Peritonitis	
6	35	1 year	53		Hemorrhage	
7	30	1 year	1	Appendectomy	Hemorrhage	
8	64	9 years	9		Pulmonary embolism	
9	53	2 months	14		Pulmonary embolism	Obesity (214 pounds).
10	55	8 years	5	Appendectomy	Bronchopneumonia	Obesity.
11	60	5 weeks	3		Bronchopneumonia	Hypertrophy of heart; acute diffuse emphysema, nephritis.
12	59	2 months	7		Uræmia	Bilateral pyelonephritis; stone obstructing right ureter.

Operation was performed March 11, 1924. The gall-bladder was completely functionless and contained stones, but no duodenal ulcer was demonstrable. The common

duct and the pancreas were normal. The gall-bladder and the appendix were excised. While the abdomen was being closed the patient stopped breathing and the pulse could not be felt. Artificial respiration and the pulmotor were used without avail. The patient died, apparently from some cardiac cause. The anæsthetic was ethylene and ether.

Necropsy showed hypertrophy of the heart (412 gm.) and old healed ulcers of the duodenum.

Case VI.—A woman, aged fifty-two, came to the clinic, March 10, 1924, because of attacks of gall-stone colic without jaundice for the last seven or eight years. The patient was obese, weighing 205 pounds, with a systolic blood-pressure of 170 and a diastolic of 90. Because of the obesity the operative risk was considered grave. She was put on a restricted diet and lost thirteen pounds in twelve days.

Cholecystectomy was performed March 24, 1924. The gall-bladder contained two stones. The stomach, duodenum, pancreas, and common duct were normal. There was moderate cirrhosis of the liver. About twenty hours after operation a marked degree of cyanosis appeared with increased pulse and respiratory rates. Examination of the chest revealed many moist râles over the bases of both lungs. The patient died on the second day after operation.

Necropsy revealed fatty changes in the myocardium, right hydrothorax (the pleura containing 100 c.c. of fluid), hypostatic pulmonary œdema and congestion.

Case VII.—A woman, aged fifty-six, came to the clinic, May 10, 1924, because of recurring attacks of gall-stone colic at irregular intervals becoming severe, often followed by jaundice. The patient was obese, weighing 200 pounds; she had a systolic blood-pressure of 166, and a diastolic of 96. At operation June 3, 1924, the gall-bladder was found to contain stones and was removed. After operation the patient complained of an unusual amount of abdominal pain, and the heart action was irregular and very fast. The patient died on the second day after operation.

The only definite lesion found at necropsy was marked fatty change in the liver. Death was probably due to acute cardiac failure.

Case VIII.—A man, aged fifty-nine, came to the clinic, March 17, 1924, because of attacks of abdominal pain, formerly followed by jaundice. Examination was essentially negative. At operation March 26, 1924, the gall-bladder was found to contain a stone, 3.7 by 4.4 cm., and also a quantity of thick pus. Its walls were about 2.5 cm. thick, and there was a moderate degree of pancreatitis. Subserous cholecystectomy was performed and the wound drained with a split rubber tube and two Penrose drains. On the fourth day after operation the abdomen was quite distended, and the pulse became rapid and weak. There was some drainage of bile on the dressings. The patient died on the sixth day after operation.

Necropsy revealed acute resolving generalized peritonitis with terminal bronchopneumonia.

Case IX.—A man, aged fifty-three, came to the clinic, November 24, 1924, because of attacks of epigastric pain which had been increasing in severity, but without jaundice. The patient was obese and weighed 174 pounds. Physical examination was otherwise negative.

At operation December 1, 1924, dense adhesions were found throughout the entire upper abdomen, chiefly around the gall-bladder. The gall-bladder and appendix were excised and a Penrose drain with gauze was inserted. The patient showed signs of bronchopneumonia, associated with marked abdominal distention, on the second day after operation. He died on the fourth day after operation.

Necropsy revealed general peritonitis.

Case X.—A man, aged thirty-five, came to the clinic, May 12, 1924, because of attacks of severe pain in the right upper abdominal quadrant. The last attack, two weeks before, had been followed by jaundice.

Operation was performed May 16, 1924. There was a good deal of infection in the region of the gall-bladder, which contained stones and had perforated into the liver.

The gall-bladder and appendix were excised. Bleeding was difficult to control and it was necessary to leave one pair of forceps and a gauze pack. Five days after operation the clamp was removed; this was followed by a sharp hemorrhage and later by drainage of bile. The patient had frequent attacks of epigastric fulness and pain with distention, and passage of bloody stools. There were repeated hemorrhages from the wound. The patient died forty-eight days after operation.

Necropsy showed that there had been leakage from the cystic duct and hemorrhage from an anomalous artery. There was a perforating ulcer of the stomach with retrogastric abscess and pancreatitis.

Case XI.—A man, aged thirty, came to the clinic, June 27, 1924, suffering from attacks of dull pain in the right lower quadrant of the abdomen. He was a well-nourished man, weighing 178 pounds. The urine contained many red blood-cells.

At operation, October 11, 1924, the gall-bladder showed chronic cholecystitis and was of the "strawberry" type. The gall-bladder and appendix were removed and a Penrose drain was placed in the gall-bladder fossa for drainage because of some general oozing. On the evening of the day of operation the patient manifested signs of internal hemorrhage, and in spite of every effort, he died on the following day.

At necropsy post-operative hemorrhage was assigned as the cause of death.

Case XII.—A woman, aged sixty-four, came to the clinic, August 13, 1924, complaining of recurring pain in the right side of the abdomen. At operation, September 3, 1924, the gall-bladder was found to contain stones and was excised. Recovery from the operation was very satisfactory, but on the ninth day the patient suddenly died from pulmonary embolism.

Necropsy revealed thrombosis of the right femoral vein and pulmonary embolism.

Case XIII.—A man, aged fifty-three, came to the clinic, November 4, 1924, complaining of attacks of severe epigastric pain. The patient was obese, weighing 214 pounds. At operation, November 11, 1924, the gall-bladder was found buried in the liver and to contain stones. Cholecystectomy was performed and a Penrose drain and strip of gauze were inserted for drainage. Convalescence was not satisfactory and the patient died suddenly on the fourteenth day after operation, apparently from pulmonary embolism.

Necropsy revealed bilateral pulmonary embolism and infarction.

Case XIV.—A man, aged fifty-five, came to the clinic, December 11, 1924, because of repeated attacks of pain about once a month, usually occurring after an indiscretion in diet. There had never been jaundice. The patient was obese and was not in good general condition.

Operation was performed December 16, 1924. The gall-bladder was distended and a stone was impacted in the cystic duct. The gall-bladder and appendix were excised. A pulmonary complication appeared shortly after operation; the patient became progressively worse, and died on the fifth day after operation.

Bronchopneumonia was found at necropsy.

Case XV.—A man, aged sixty, came to the clinic, June 14, 1924, because of soreness in the right side of the abdomen. At operation, June 21, 1924, a large, hard, inflammatory mass was found in the upper right quadrant. It was composed of the gall-bladder, omentum, and hepatic flexure of the colon, and probably was caused by a perforation of the gall-bladder. The appendix was not involved. The gall-bladder was excised with considerable difficulty. A cholecystocolic fistula could not be demonstrated. Drainage was instituted by rubber tubes and gauze packs. The patient's condition was serious after the operation; he passed no urine, and died on the third day.

Necropsy revealed bronchopneumonia, chronic emphysema with hypertrophy of the right side of the heart, and acute diffuse nephritis. The pneumonia was the probable cause of death.

Case XVI.—A man, aged fifty-nine, came to the clinic, September 8, 1924, complaining of pain in the abdomen. The blood urea was 96 mg. for each 100 c.c. Operation

was performed September 9. The abdomen was filled with very dense adhesions, evidently the result of old tuberculous peritonitis. The gall-bladder was distended, subacutely inflamed, and contained a number of stones, one of which was impacted in the cystic duct. The gall-bladder was excised and the adhesions about the ileocæcal coil were freed. A strip of gauze and a Penrose drain were used. Five days after operation there was a marked rise in the temperature and pulse. The blood urea was 192 mg. and the creatinin 4.4 mg. for each 100 c.c. The patient became comatose, failed rapidly, and died on the seventh day after operation.

Necropsy revealed chronic bilateral pyonephritis with atrophy of the left kidney (55 gm.), right obstructive nephrolithiasis with acute diffuse nephritis, compensatory hypertrophy of the right kidney (267 gm.), and terminal bronchopneumonia. Death evidently was due to uræmia.

Comment.—Four of the twelve patients on whom cholecystectomy was performed were described as obese. It is an accepted fact that obesity adds to the surgical risk. Many surgeons have markedly and rapidly reduced the weight of patients immediately prior to operation, in the erroneous belief, we think, that this would protect the patient to some degree against post-operative complications. This rapid reduction likewise reduces the general resistance and recuperative powers which are needed to combat the added stress of operative trauma. Therefore, it is often absolutely contra-indicated before an operation. If reduction of weight seems necessary, the patient should be put on a suitable diet and the weight reduced slowly; a few days before the appointed time of operation an unrestricted diet should be permitted. We believe that this is another method by which with proper management the mortality rate of operations on obese patients will be lowered. Of the four obese patients in this group who died, two died from cardiac disease, one from pulmonary embolism, and one from bronchopneumonia. Cardiac and pulmonary complications may be expected in the obese more often than in patients of different build. The instance of pulmonary embolism typifies that unfortunate and hopeless condition which in our experience usually develops in the second week after operation and which all surgeons dread. In Case VI the obese patient had been rapidly reduced in weight immediately before operation. The death illustrates our observation that this is not the correct method of preparing a patient of this type for operation. It will be seen that there were only two patients under fifty-two years of age, thirty and thirty-five years, respectively, and both of these died from post-operative hemorrhage, one of which came from an anomalous artery. The age incidence in this group is very interesting; the ages were between thirty and sixty-four years, the average being 52.5 years; the two youngest died from post-operative hemorrhage. Of the two who died from peritonitis, one suffered from empyema of the gall-bladder and pancreatitis at the time of operation. This might be considered sufficient cause for the peritonitis, but in the other the complication could not be explained. In Cases XV and XVI, in view of the pathologic findings, the surgical risk was preëminently grave; in each there was a rather short history of illness, severe and acute enough to make surgical intervention necessary. In six of these twelve cases in which death occurred, the patient must be considered very questionably suited for operation. In

two others death was attributable to conditions over which we have little or no control (pulmonary embolism in one and cardiac disease at the time of operation in the other). In still another death was caused by hemorrhage from an anomalous artery. The study of this series has been very interesting and enlightening to us.

ANALYSIS OF CAUSES OF DEATH FOLLOWING OPERATIONS FOR CHRONIC CHOLECYSTITIS AND ASSOCIATED LESIONS (TABLE IV)

CASE XVII.—A man, aged thirty-seven, came to the clinic, June 9, 1924, complaining of periodic attacks of epigastric distress, occurring from three to four hours after meals. At operation, June 20, a duodenal ulcer was excised, and the gall-bladder, which appeared diseased, was removed. The liver showed marked hepatitis. A pulmonary complication

TABLE IV

Mortality Following Operations for Chronic Cholecystitis and Associated Lesions

Operations		Hospital mortality	
		Cases	Per cent.
Cholecystectomy with			
Operation for peptic ulcer with or without appendectomy	36	1	2.7
Herniotomy, with or without appendectomy	14		
Pelvic operation, with or without appendectomy	9		
Excision or drainage of pancreatic duct	2		
Dissection of biliary fistula, herniotomy	1		
Closure of cholecystocolonic fistula	1		
Appendectomy, pyloroplasty, enucleation of parovarian cyst	1		
Gastrorrhaphy, herniorrhaphy (diaphragmatic)	1		
Nephropexy	1		
Closure of cholecystoduodenal fistula	1		
Entero-anastomosis for obstruction; gastro-enterostomy.	2		
Cholecystostomy with			
Posterior gastro-enterostomy for peptic ulcer, with or without appendectomy	4		
Excision of abscess and sinus of abdominal wall	1		
Drainage of subhepatic abscess	1		
Drainage of pseudopancreatic cyst	1		
Total	76	1	1.3

appeared on the day after operation; the patient became progressively worse and died the following day. There were definite signs of bilateral bronchopneumonia. Necropsy was not permitted.

OPERATIONS ON THE GALL-BLADDER AND COMMON DUCT

Operation was performed on the gall-bladder and common duct in 142 cases (Table V). This group represents a type of case in which the surgical risk is generally considered grave. In many of these cases jaundice is evident at the time of examination, or some degree of it has just disappeared after being present for variable periods. Even in the absence of icterus, one must not forget the importance of the so-called "delayed jaundice," where oozing

TABLE V

Mortality Following Operations on the Gall-bladder and Common Duct for Benign Conditions

	Operations	Hospital mortality cases
Stones in the gall-bladder or ducts		
Cholecystectomy and choledochostomy	58	1
Cholecystectomy and exploratory choledochostomy	9	..
Cholecystectomy, choledochostomy, herniotomy, appendectomy	1	..
Choledochostomy	18	1
Cholecystostomy and choledochostomy	16	2
Cholecystostomy and exploratory choledochostomy	4	..
Cholecystectomy, choledochostomy, and repair of cholecystoduodenal fistula	3	..
Cholecystostomy, choledochostomy, and repair of cholecystoduodenal fistula	1	..
Choledochostomy and repair of duodenal fistula	1	1
Cholecystectomy, choledochostomy, and repair of cholecystocolonic fistula	2	..
Cholecystectomy, choledochostomy, and reconstruction of the ducts	1	..
Cholangeitis, hepatitis, pancreatitis		
Choledochostomy	3	..
Cholecystoduodenostomy	1	1
Biliary cirrhosis		
Choledochostomy	2	..
Fistula or stricture of the common duct		
Hepaticoduodenostomy	11	2
Hepaticogastrostomy	2	..
Choledochoduodenostomy	1	1
Resection of stricture of the common duct	2	..
Choledochostomy for stricture	4	1
Exploration of biliary fistula	1	1
Cholecystectomy and reconstruction of common duct	1	..
Total	142	11 (7.7%)

and bleeding may be as troublesome as in cases of frank jaundice. Moreover, in some of these cases request for medical advice is postponed until it was imperative for their relief. Some of these are old chronic cases in which infection has extended into the liver, pancreas, and generally along the bile ducts, causing œdema and variable degrees of infections, with or without stones or obstruction of bile. Again, in many of them operation has been performed previously, and relief is sought because of the recurrence of the same old attacks of pain, or jaundice, or both. This group represents a class which demands extensive and rather heroic operative measures for cure, or even for improvement. Perhaps no other branch of surgery offers such technical difficulties as some of the operations on the common duct performed in a series of 142 consecutive cases; it is surprising that the mortality is as

low as it is. In all probability, this low mortality rate is due not only to the selection of cases for operation, but to the pre-operative preparation of all patients showing an abnormal content of serum bilirubin, and to detailed post-operative management so necessary in these cases.

ANALYSIS OF CAUSES OF DEATH FOLLOWING 142 OPERATIONS ON THE COMMON DUCT FOR BENIGN CONDITIONS (TABLE VI)

CASE XVIII.—A man, aged sixty-four, came to the clinic because of chills and fever. Symptoms had lasted intermittently for ten years. Operation, April 21, 1924, revealed a marked degree of biliary cirrhosis and the duodenum sealed onto the common duct. A stone about 2.5 cm. in diameter was removed from the common duct together with several small stones and a good deal of débris. A fistulous tract between the common duct and the duodenum was closed. A rubber catheter was sewed into the common duct for drainage, and the gall-bladder, which was practically functionless, was not disturbed. On the fifth day symptoms of pneumonia appeared; they were confirmed by physical and röntgenologic examination of the chest. Death occurred nine days after operation.

Necropsy revealed extensive bronchopneumonia and a marked degree of biliary cirrhosis.

CASE XIX.—A woman, aged sixty-six, came to the clinic, January 5, 1924, because of former jaundice and attacks of epigastric colic. There was no jaundice at the time of examination. At operation January 10, the gall-bladder was found distended and filled with stones, with much pericholecystitis. The common duct was markedly dilated. Thirty cubic centimetres of pus, together with numerous stones, was removed from the gall-bladder; eighteen stones were taken from the common duct, and several stones were also removed from the hepatic duct. The gall-bladder was drained and a catheter was sewed into the common duct for drainage. The patient developed pneumonia on the second day after operation, and died on the third day after operation. Pneumonia was the probable cause of death. Necropsy was not permitted.

CASE XX.—A man, aged fifty-four, came to the clinic, June 1, 1923, because of jaundice. Examination revealed a moderate degree of jaundice and cachexia. Hæmoglobin was 68 per cent., and the coagulation time was eight and one-half minutes.

Operation revealed biliary cirrhosis, a small gall-bladder which collapsed easily, very great enlargement of the regional lymph-nodes, and enlargement of the pancreas, which, however, did not seem to be malignant. Because of the patient's condition only cholecystostomy was performed. The patient recovered and was allowed to return home.

He returned for a second examination eleven months after operation. He had lost weight and strength, and the jaundice had persisted and become deeper. Examination showed an intense degree of jaundice; the patient appeared very weak, and weighed only 149 pounds. The findings at operation were essentially those previously noted. Anastomosis was made between the gall-bladder and the duodenum. The output of urine was low, and the temperature and pulse elevated. The patient became drowsy; œdema of the hands and feet appeared, and the blood urea rose from 48 to 176 mg. He died on the eleventh day after operation.

Necropsy revealed chronic cholangeitis with biliary cirrhosis, intraperitoneal hemorrhage, and bronchopneumonia.

CASE XXI.—A woman, aged fifty-two, came to the clinic, January 27, 1923, because of pain beneath the right costal margin. The gall-bladder had been drained and a large number of stones removed elsewhere nine years previously.

At operation January 31, a stone was removed from the common duct and also one from the hepatic duct. The gall-bladder also contained multiple stones and was excised. There was no jaundice. She recovered. Recurrence of pain and jaundice a year later demanded further operative treatment. On examination there was a marked degree of

TABLE VI

Analysis of Death Following 142 Operations on the Common Duct for Benign Disease

Case	Age, years	Duration of symptoms, years	Character of jaundice	Previous operations	Operation	Days lived after operation	Cause of death	Associated disease.
1	64	10	Intermittent	None	Choledochostomy for stones and closure of duodenal fistula	9	Bronchopneumonia	Cholecystoduodenal fistula.
2	66	19	Absent	None	Cholecystostomy and choledochostomy for stones	3	Pneumonia. (Necropsy refused)	None.
3	55	2	Constant	Cholecystostomy one year before	Cholecystoduodenostomy	11	Pneumonia and intraperitoneal hemorrhage	Chronic cholangeitis; biliary cirrhosis.
4	53	10	Constant	Cholecystectomy and choledochostomy sixteen months before	Choledochostomy for stone	5	Hepatic insufficiency	Chronic atrophy of the liver.
5	32	14	Constant	Cholecystostomy eight years before	Cholecystostomy and choledochostomy for stone	2	Hemorrhage	None.
6	36	0.5	Constant	Cholecystectomy six months before	Reconstruction of common duct for stricture	12	Hemorrhage. (Necropsy refused)	None.
7	42	3	Absent	None	Cholecystectomy and choledochostomy	16	Bronchopneumonia; stones in hepatic duct	Multiple active duodenal ulcers.
8	56	1.5	Intermittent	Cholecystectomy eighteen months before	Reconstruction of common duct for stricture; repair of ventral hernia	1	Hemorrhage	Ventral hernia; marked coronary sclerosis; chronic infarction of myocardium.
9	22	0.17	Absent	Cholecystectomy two months before	Exploration of biliary fistula	3	Hemorrhage	Biliary fistula.
10	28	0.5	Constant	Cholecystostomy and cholecystectomy six months before	Choledochostomy for stricture	7	Hepatic insufficiency	Hepatitis; nephritis.
11	5 months	0.42	Constant	None	Exploration for congenital obliteration of common duct	2	Hepatic insufficiency	Biliary cirrhosis.

jaundice and the patient was confined to bed. Coagulation time was seven minutes. At operation May 20, 1924, a large stone in the ampulla of the common duct and several smaller stones were removed from the common duct and a T-tube inserted into the duct for prolonged drainage. There was good drainage of bile after the operation. However, the patient failed rapidly and died on the fifth day after operation.

Necropsy revealed only a slight amount of hemorrhage, and chronic atrophy of the liver with biliary stasis. The cause of death was probably hepatic insufficiency.

CASE XXII.—A woman, aged thirty-two, came to the clinic, December 12, 1924, because of attacks of gall-stone colic at intervals for the last fourteen years. In December, 1916, cholecystostomy for stones had been performed elsewhere. The patient has recently lost considerable weight; examination showed an intense degree of jaundice. Hæmoglobin was 76 per cent.; the leucocytes numbered 12,900, and the coagulation time was six and one-half minutes. Calcium chlorid was given in preparation for operation.

At operation the common duct was dilated to a diameter of 1.5 cm. and the bile came out under great pressure when the duct was opened. The obstruction was due to a single stone impacted in the ampulla. The gall-bladder, which was distended with bile but contained no stone, was removed. There was sudden failure on the day after operation, apparently from hemorrhage, and the patient died within a few hours.

Necropsy revealed hemorrhage into the common duct and abdominal cavity.

CASE XXIII.—A woman, aged thirty-six, came to the clinic, November 7, 1924, because of jaundice becoming progressively deeper. Cholecystectomy for stones had been performed elsewhere six months before, and jaundice had appeared six weeks after the operation. There had been no pain at any time. Examination showed a moderate degree of jaundice. The hæmoglobin was 60 per cent., and the blood urea was 46 mg. for each 100 c.c. There was dye retention, Grade 4, and the serum bilirubin was 7.5 mg. for each 100 c.c. The coagulation time was nine minutes.

At operation, November 26, a stricture of the common duct was found. The duct was reconstructed over a T-tube. There were several hemorrhages after operation. Drainage of bile was not good, and the stools remained clay-colored. Serum bilirubin was 7.8 mg. for each 100 c.c. The patient died on the twelfth day after operation. Death was apparently due to hemorrhage and peritonitis. Necropsy was not permitted.

CASE XXIV.—A man, aged forty-two, came to the clinic for examination October 31, 1924. He had lost thirty pounds in weight in the last four months, and appeared undernourished and weak. There was no free hydrochloric acid, and the röntgenograms showed duodenal ulcer.

At operation, November 7, the pylorus and duodenum were found densely adherent to the liver and gall-bladder, and it was difficult to be certain about the presence of an ulcer. The common duct was considerably dilated, but no stone could be found. The gall-bladder was removed and a catheter inserted into the common duct for drainage. On the sixth day the patient became nauseated, and lavage of the stomach showed retention of 300 c.c. There was very free drainage of bile from the tube. There was a steady rise in temperature and pulse, with moderate cyanosis. The patient died on the sixteenth day after operation.

Necropsy revealed several stones in the hepatic duct, left bronchopneumonia, and multiple active duodenal ulcers.

CASE XXV.—A man, aged fifty-six, came to the clinic, November 19, 1924. In 1921 he had been operated on elsewhere for abdominal adhesions and injury to the liver. In May, 1923, the gall-bladder had been removed. At examination a mild degree of jaundice was found. The coagulation time was five minutes. There was dye retention, Grade 3, but the serum bilirubin was only 2.9 mg. for each 100 c.c.

Operation, November 27, revealed a stricture of the common duct. The bile was under considerable tension and the hepatic duct contained much débris. The common duct was reconstructed over a piece of rubber tube. On the evening of the day of operation the pulse became rapid and weak. The patient died early the next morning.

Necropsy revealed retroperitoneal and intraduodenal hemorrhage which probably came from one of the large pancreaticoduodenal vessels. There was marked coronary sclerosis and chronic infarction of the myocardium.

CASE XXVI.—A woman, aged twenty-two, came to the clinic, October 8, 1924, because of a biliary fistula. The gall-bladder, containing a stone, had been excised elsewhere three months before. Complete biliary fistula had persisted since the operation. The patient was emaciated and weighed only ninety-nine pounds. No bile was found in the stools.

At operation, October 10, 1924, a small abscess was found on the under surface of the liver. The proximal end of the common duct could not be found. Bile drained freely from the edge of the liver in the region of the hepatic duct. The portal vein was accidently opened, but was apparently closed satisfactorily. The operation consisted of the insertion of a catheter into the hepatic duct. There was no drainage of bile from this tube after operation. There was a marked amount of oozing from the wound after operation. The patient died on the third day, apparently from hemorrhage.

Necropsy revealed hemorrhage from the portal vein and obliteration of the common duct.

CASE XXVII.—A man, aged twenty-eight, came to the clinic, June 6, 1924, complaining of jaundice. The gall-bladder had been removed elsewhere six months before. Increasing jaundice had recently been present. Examination showed an intense degree of jaundice with bile in the urine. The coagulation time was seven minutes. The patient was prepared for operation by intravenous injections of calcium chlorid.

At operation, June 20, there was a stricture of the common duct, but because of the patient's condition it did not seem advisable to do more than insert a catheter into the hepatic duct for drainage. Following operation there was considerable oozing of blood, and the patient died on the seventh day after operation.

Necropsy revealed that the duct had been tied off at the previous operation. There was considerable hemorrhage from the wound. Hepatitis and nephritis were present.

CASE XXVIII.—A fmale infant, aged five months, was brought to the clinic December 3, 1924, because complete jaundice had persisted since birth, and there had been no bile in the stools at any time. Examination showed an enlarged liver and spleen, a marked degree of jaundice, and bile in the urine. The hæmoglobin was 60 per cent. The Wassermann test was negative. The coagulation time was five and one-half minutes and the serum bilirubin was 16.1 mg. for each 100 c.c. of blood. A diagnosis was made of congenital abscess of the common duct.

At operation, December 11, the gall-bladder was found buried in the liver. The common duct could not be identified accurately, but the gall-bladder and what appeared to be the common duct were anastomosed to the duodenum. The patient died on the following day.

Necropsy showed congenital obliteration of the common bile duct, cirrhosis of the liver, and hypertrophy of the spleen.

Comment.—In this group there were five males and six females. The ages ranged from five months to sixty-six years, the average being forty-one and a half years. In seven of the eleven cases previous operations on the biliary tract had been performed; in five of these it was cholecystectomy, with drainage of the common duct in one, and in another cholecystostomy had been performed previously. In four no previous operation had been performed. Jaundice was present in eight (Grade 2 to 4) at the time of examination. Stones had been found at the time of the primary operation in seven instances. Biliary cirrhosis was an important finding in three instances, and in three marked retention of dye existed. Hepatitis, biliary cirrhosis, atrophy of the liver, abscess of the liver, and also associated pancreatitis were found fre-

quently, all probably due to the retention of bile causing varying degrees of infection.

In studying these cases, we are impressed by the great responsibility a surgeon assumes when he undertakes any operation on the biliary tract, however simple the procedure may be. Even slight injury to the common duct may cause the patient an irremediable amount of future trouble. In reviewing secondary operations for stricture of the common duct over a period of six years, we find convalescence long and irregular and end results doubtful, in many cases disappointing. Post-operative hemorrhage has been a prominent complication in this group in spite of pre-operative preparation with calcium chlorid and oftentimes with blood transfusions, which have probably reduced this threat to a minimum. Post-operative treatment of this complication by the same methods doubtless has been of some value, yet hemorrhage is among the most important of the immediate dangers. Perhaps the greatest lesson to be learned from this group is that careful and intelligent surgery should be practiced at the time of the primary operation. Such prophylactic measures will do much to reduce the number of these cases which later demand urgent and extensive operative procedure in an attempted repair of damage done at the former operation. This applies chiefly to post-operative stricture.

Another group of cases requiring secondary operations are those associated with recurring attacks of colic or jaundice, or both, and which are found later to be due to stones in the bile ducts. It is never possible to know with certainty at the time of operation that all stones have been removed from the ducts. Probably a great many of the recurring attacks following operations for stones in the gall-bladder or ducts are due to stones overlooked at the time of the first operation. It is possible for stones to form in the ducts after cholecystectomy or after the drainage of the common duct, but in the majority of cases, the offending stone or stones were present at the time of the previous operation.

What more could be done to reduce the mortality? We are preparing the patients before operation by all means known to us to prevent hemorrhage and to get the patient in the best possible condition. Fluids are forced; a diet high in carbohydrates is given, and we try to wait, if possible, until the serum bilirubin is reasonably near normal limits. In many instances this is not possible and we must assume the risk, with the knowledge that the patient and his relatives understand the risk involved, and resort to operation without delay. The coëxisting hepatic and pancreatic disease must be taken along with the dangers of hemorrhage, and operation performed, as the only hope lies in surgical measures. The results naturally depend on the findings at the time of operation. Adequate drainage is imperative. In two of the cases in this group the condition of the patient was very bad, and so much scar tissue was found that the common duct could not be identified. As extensive procedures were contraindicated at the time, it seemed best merely to drain the hepatic duct with a catheter in the hope that a secondary operation could be performed at a later time when the patient was in better condition.

OPERATIONS FOR CARCINOMA OF THE GALL-BLADDER OR BILE DUCTS (TABLE VII)

Operations for carcinoma of the gall-bladder or ducts are obviously rather hopeless at the start. Operation of some nature, even though a simple exploration, is justifiable for alleviating the often present intolerable symptoms. Occasionally the institution of proper biliary drainage by means of cholecystogastrostomy, or some other type of anastomosis, will make the last days of the patient fairly comfortable. In many of these cases more or less typical symptoms of disease of the gall-bladder have lasted for years. At the time of examination intense jaundice may have been present, and operation seemed advisable and justified by the history. However, at operation a neoplasm presents itself, and operation, no matter how extensive, will not effect a cure. In most cases the malignant disease of the gall-bladder is probably ingrafted upon an old chronic infection, usually when stones have been present for a long period of time. Many operations in this group therefore resolve themselves into purely exploratory measures while others are at best only palliative. In a few cases some benefit is derived from operations which provide proper biliary drainage, but the end result is usually discouraging.

TABLE VII

Mortality Following Operations for Carcinoma of the Gall-bladder or Ducts, with or without Stones

	Operations	Hospital mortality	
		Cases	Per cent.
Exploration (specimen removed in six)	9	..	..
Cholecystectomy	4	1	..
Cholecystectomy and exploratory choledochostomy	1	..	..
Cholecystostomy and removal of specimen	2	..	..
	16	1	6.2

DETAILED ANALYSIS OF DEATH FOLLOWING CHOLECYSTECTOMY FOR CARCINOMA OF THE GALL-BLADDER WITH STONES

CASE XXIX.—A woman, aged sixty-three, came to the clinic because of jaundice. Attacks of biliary colic had lasted for twenty-six years, and jaundice had appeared after the last attack. The patient had lost twenty-three pounds in the last two or three months. Examination showed an intense degree of jaundice, and the liver was enlarged. The coagulation time was seven minutes. There was dye retention of Grade 4. Serum bilirubin was 33.8 mg. for each 100 c.c. The patient was prepared for operation by intravenous injection of calcium chlorid.

At operation the gall-bladder was found to contain stones and there was an extensive carcinoma involving the gall-bladder, hepatic duct, and the liver. Partial cholecystectomy was performed and the stones removed. There was considerable oozing of blood after operation. Death occurred on the fourth day after operation.

Necropsy revealed carcinomatous obstruction of the hepatic duct, and hemorrhage in the operative field, intestines and uterus.

OPERATIONS FOR PANCREATIC LESIONS

Because the pancreas is intimately connected with the biliary tract, both physiologically and pathologically, pancreatic lesions are included in the study of the hospital mortality following operations on the biliary tract (Table VIII).

TABLE VIII

Mortality Following Operations on the Pancreas

	Operations	Hospital mortality	
		Cases	Per cent.
Cholecystectomy and drainage of pancreatic cyst	2	..	..
Drainage of cysts of the pancreas	6	2	..
Drainage for pancreatitis with excision of specimen	1	..	..
Pancreatitis and malignant diseases of the pancreas			
Exploration	6	..	..
Cholecystogastrostomy	5	1	..
Cholecystocolostomy	1	1	..
Cholecystostomy	1	1	..
Exploration, cholecystopexy	1	..	..
Exploration (sarcoma)	2	..	..
	25	5	20

ANALYSIS OF CAUSES OF DEATH FOLLOWING OPERATIONS FOR PANCREATIC LESIONS

CASE XXX.—A woman, aged twenty-one, came to the clinic because of pains in the abdomen and back increasing in severity during the previous four months. Examination showed a large tumor in the right hypochondriac region. The blood urea was 48 mg. for each 100 c.c. Operation revealed a large retroperitoneal tumor in the upper abdomen. The tumor was apparently a cyst and was explored with a trocar; clear fluid was obtained but the entire tumor did not collapse. The cyst was marsupialized and two rubber tubes were inserted for drainage. Convalescence was apparently satisfactory for about four weeks when a duodenal fistula developed. There was progressive failure from this time and she died eleven weeks after operation.

Necropsy revealed digestion of the posterior wall of the duodenum with duodenal fistula.

CASE XXXI.—A woman, aged thirty-four, came to the clinic, June 14, 1924, because of a sudden severe pain in the epigastrium associated with vomiting and requiring opiates for relief. A mass had been present in the upper abdomen for nine years, but for three weeks before examination in this clinic there had been constant pain and excessive emesis, and the abdomen had been markedly distended. The mass was slightly tender to pressure. The patient was very obese. Albumin and a few pus cells were found in the urine.

At operation there was considerable straw-colored fluid in the peritoneal cavity. There was a retroperitoneal tumor behind the stomach and some fat necrosis of the omentum. The gall-bladder was distended. About 1000 c.c. of thin purulent fluid was evacuated from the tumor, the cavity of which contained considerable necrotic material. Two rubber tubes were inserted for drainage. After operation the patient continued to have a great deal of abdominal distention. Bilateral parotitis appeared on the third day. The temperature and pulse rate increased, and the patient died on the fourth day after operation.

Necropsy revealed chronic suppurative pancreatitis with multiple abscesses, general

peritonitis, and fat-necrosis. There were stones in the gall-bladder and in the common duct; there was terminal œdema of the lungs with pneumonia.

Case XXXII.—A man, aged sixty-two, came to the clinic because of moderate epigastric pain during the previous five months. Examination showed a slight degree of jaundice. The urine contained albumin and pus. There was dye retention, Grade 4. The serum bilirubin was 27.8 mg., and the coagulation time was six minutes. Intravenous injections of calcium chlorid were given as a pre-operative measure.

At operation a diffuse neoplasm of the pancreas with lymphatic involvement was found, and the gall-bladder and the common duct were distended. The gall-bladder was anastomosed to the colon. There was very little change in the degree of jaundice. The patient died on the seventeenth day after operation.

Necropsy revealed carcinoma of the head of the pancreas with obstruction of the common and hepatic ducts, multiple cysts and necrosis of the pancreas and general peritonitis.

Case XXXIII.—A man, aged fifty-seven, came to the clinic because of pain in the right side with occasional vomiting. One time he had a chill followed by jaundice. There was sugar in the urine. Hæmoglobin was 65 per cent. The diabetes was controlled by treatment. Operation was then advised for disease of the gall-bladder.

At operation the gall-bladder was markedly distended. There was a large soft tumor in the head of the pancreas, the nature of which could not be definitely determined. No stones could be felt in the gall-bladder or the common duct. Cholecystogastrostomy was performed. On the second day after operation the patient showed signs of bronchopneumonia and died on the fourth day. Necropsy was not permitted.

Case XXXIV.—A woman, aged seventy-two, came to the clinic because of three attacks of severe pain in the right upper abdomen which had occurred during the last year, the last being followed by persistent jaundice.

At operation there were stones in the gall-bladder, hepatic duct, and common duct, and one was impacted in the ampulla of the common duct. Definite pancreatitis and hepatitis were present. The stones were removed from the ducts and drainage was instituted. The patient returned for examination ten months after the operation because of painless jaundice. The coagulation time was ten minutes, and there was dye retention, Grade 4.

At the second operation the gall-bladder was found to be thick-walled and did not contain bile. The common duct was dilated and the head of the pancreas was small and hard. The gall-bladder was drained. Drainage of bile appeared on the day after operation and continued in good amounts. In spite of this drainage the jaundice did not diminish and the patient's condition became progressively worse. She died on the twentieth day after operation. Necropsy was not permitted. Death was probably due to the effects of biliary obstruction and renal insufficiency since the blood urea rose to 179 mg. for each 100 c.c.

Comment.—In Case XXXII cholecystocolostomy was performed and in Case XXXIII cholecystogastrostomy. At the time of the operation it was realized that these procedures were palliative only, but seemed advisable, as they promised at least some relief from the jaundice. Palliative operations such as these are certainly worth while even in the presence of very extensive malignant disease, with the full knowledge that the surgical risk is thereby increased. In such instances as Case XXXIV, when the pancreas shows distinct changes and it is impossible to say whether the lesion is a carcinoma or pancreatitis, institution of free biliary drainage is good surgery. If it is carcinoma, the patient may be relieved, while, as is often the case, if it is pancreatitis, this adequate drainage may effect a permanent cure. This has

been demonstrated repeatedly by the work of Mallet-Guy and Berard, who insist on adequate drainage of bile whatever the method employed. It is in such cases as pancreatitis that encouraging results are occasionally obtained and prove that such operations are well worth the added risk.

DETAILED ANALYSIS OF TWO DEATHS FOLLOWING DRAINAGE OF LIVER ABSCESSES (TABLE IX)

CASE XXXV.—A man, aged thirty-one, came for examination because of chills and fever of nine months' duration and severe pains in the lower part of the left side of the chest. At the time of examination the temperature was 102° and the leucocytes numbered 21,200. A sinus discharging pus in the right chest wall was a relic of a previous operation for empyema. At operation multiple abscesses of the liver were drained. After operation remittent fever ranged from 98 to 103°. There was dye retention, Grade 2. The patient died the seventeenth day after operation, clinically from septicæmia.

TABLE IX

Mortality Following Operations on the Liver

	Operations	Hospital mortality cases
Abscess		
Drainage	7	2
Biliary cirrhosis		
Exploration	2	..
Cirrhosis		
Talma-Morrison operation	9	2
Hepatitis		
Exploration	1	..
Cyst		
Removal of echinococcus cyst	1	..
Malignant disease of the liver		
Exploration (excision of specimen in four)	6	..
Total	26	4 (15.3%)

Necropsy revealed multilocular abscesses of the liver with sinus, old healed right empyema, terminal multiple abscesses of the lung, left empyema (200 c.c.), thrombosis of the left femoral, internal and external iliac veins with pulmonary embolism and infarction and chronic appendicitis. Cultures from the lung grew a hæmolytic streptococcus and from the liver *Bacillus fusiformis*, spirilla and *Bacillus coli*.

CASE XXXVI.—A man, aged thirty-three, came to the clinic, July 14, 1924, complaining of hæmoptysis and subsequent expectoration of large amounts of foul, dark material, preceded by and relieving pain in the upper abdominal and right suprascapular regions. Pelvic abscesses, following appendicitis, had been drained previously. At examination the liver was found to be much enlarged, and breath sounds were diminished over the lower part of the right chest. Röntgenograms of the chest showed the right diaphragm elevated. July 20, under local anæsthesia, multiple abscesses of the liver were drained. The temperature was typical of sepsis, and the leucocytes ranged from 18,000 to 54,000. A right pleural effusion was twice aspirated, but death occurred the fourteenth day after operation. Clinically the cause of death was multiple abscesses of the liver, peritonitis, and bronchopneumonia. Necropsy was not permitted.

DETAILED ANALYSIS OF TWO DEATHS AFTER TALMA-MORRISON OPERATION (TABLE IX)

CASE XXXVII.—A woman, aged sixty, came to the clinic because of swelling of the abdomen of three months' duration, associated with jaundice and swelling of the feet and ankles. The effects of paracentesis had been transient. Examination showed a slight degree of jaundice. The abdomen contained a large amount of fluid and there was œdema of the extremities. The urine contained albumin. The coagulation time was seven minutes. The blood urea was 32 mg. for each 100 c.c.

At operation 8000 c.c. of straw-colored, slightly cloudy fluid was withdrawn. The liver was very small, firm and nodular and the gall-bladder was distended. There was no evidence of malignant disease. A Talma-Morrison operation was performed. The patient died on the eighth day after operation.

Necropsy revealed portal cirrhosis of the liver (953 gm.) with splenomegaly (370 gm.), ascites (3000 c.c.), anasarca, chronic diffuse nephritis, terminal hypostatic congestion of the lungs, hypertrophy of the heart (360 gm.), and a marked degree of arteriosclerosis.

CASE XXXVIII.—A woman, aged fifty-seven, came to the clinic because of recurring attacks of epigastric pain of twelve years' duration, accompanied by nausea and vomiting. Examination showed a distended abdomen which apparently contained free fluid. There was marked œdema of the lower extremities. The hæmoglobin was 63 per cent. and the leucocytes numbered 12,200. Röntgenograms of the chest showed fluid in the right pleural cavity.

At operation more than 8000 c.c. of fluid was removed from the abdomen. The liver was small and cirrhotic, and the gall-bladder contained stones which were not disturbed. A Talma-Morrison operation was performed. After operation the fluid again accumulated in the abdomen and 8000 c.c. more of straw-colored fluid was removed. The patient died thirty-four days after operation.

Necropsy revealed portal cirrhosis (948 gm.) with ascites, bilateral hydrothorax and anasarca, cholelithiasis with dilatation of the gall-bladder and ducts, a moderate degree of jaundice and dilatation of the œsophageal and diaphragmatic veins.

Comment.—In the two cases of abscess of the liver it is seen that the drainage in each instance was a secondary procedure following drainage of foci elsewhere in the body, one an empyema and the other a pelvic abscess following rupture of the appendix. In both cases, the risk was high but was accepted, as operative interference was imperative.

In the two cases in which the Talma-Morrison operation had been performed, the patient was in extremis at the time of operation. In both there was a large amount of ascitic fluid and in one, jaundice. This type of operation has given good results in some instances, but in the presence of large amounts of ascitic fluid with great destruction of the substance of the liver, and jaundice, a Talma-Morrison operation, like any other form of treatment, is likely to fail. It is well worth while, however, as a palliative procedure, and especially so, since the added risk is not great and there is little else left to do.

PROGRESSIVE GANGRENOUS INFECTION OF THE SKIN AND SUBCUTANEOUS TISSUES, FOLLOWING OPERATION FOR ACUTE PERFORATIVE APPENDICITIS *

A STUDY IN SYMBIOSIS

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The object of this communication is to report the histories of two cases of extensive destruction of the skin and subcutaneous areolar tissues, from infections occurring in the operative wounds of cases of acute perforative appendicitis.

While all surgeons are familiar with the various types of wound infection, following operations on septic conditions of the various abdominal viscera, necessitating contamination of the wound surfaces during the operative procedures, or following the drainage of these septic foci; few such superficial infections give rise to serious apprehension, when the intra-peritoneal focus ceases to extend, and progresses normally toward recovery.

In practically all such cases, it is the deep-seated primary intra-abdominal infective process which causes anxiety; and not the superficial secondary stitch abscess or subcutaneous cellulitis, for these almost invariably are controlled by the simple procedure, of removal of sutures and establishing drainage of the subcutaneous space.

In the cases which I am reporting here, the opposite of this condition prevailed, and persisted to such an extent, as to give rise to the greatest anxiety.

The progress of this infection was not rapid, as in a post-operative erysipelas, a streptococcus cellulitis, or gas bacillus infection; nor was it associated with high fever and grave toxæmia usually present in these acute conditions. It was on the other hand, exceedingly slow, extending only one or two centimetres in the course of a week or ten days, and with little or no fever or evidences of toxæmia. This type of infection seemed singularly rebellious to any and all kinds of ordinary wound treatment. It was apparently uninfluenced by local incisions, drainage, irrigation, heat, cold, Carrel-Dakin technic, or by the employment of other chemical disinfecting agents. It was not benefited by sunlight, Alpine light, or any other form of radiant energy.

The process may perhaps best be described, as a slowly advancing white subcutaneous slough. The skin lesion, occurring somewhat later, appeared at first as a deep red or purple superficial œdema, which later slowly broke down into a necrotic mass resembling an untreated carbuncle. This in turn was surrounded by a zone of lighter colored erythema, which gradually faded out into the normal skin. At times the subcutaneous necrotic area and cutaneous margins would assume a dark gray, or even black color. Beneath the

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sloughing area, which varied considerably in extent, sometimes being limited to the upper third of the subcutaneous fat, and at others extending well down to the deep aponeurosis; there was always a layer of granulation tissue, which seemed to be a definite but ineffectual effort of repair.

In both of my cases the process seemed to start at the upper part of the cutaneous wound, and gradually crept downward along both margins toward the site of the intra-peritoneal drain opening. The actual site of the deep drainage cavity was apparently never involved.

Without dwelling further on the special wound features of this infection, which will best be shown in the accompanying illustrations, I will briefly report the clinical features of the two cases; which in history, sequence of events, and wound appearances, seemed identical.

Case I.—H. B. T., age thirty-two, an apparently robust and healthy man of good habits, and without evidence of chronic infectious or degenerative disease; while on a visit to New York, experienced a sudden attack of acute abdominal pain associated with all the characteristic symptoms and signs of an acute fulminating appendicitis. As he was alone in a hotel he did not obtain expert advice for two days. At the time the writer first saw him in consultation with Doctor Mitchell, he had a temperature of 103, pulse 90. The abdomen was moderately distended and tender in all four quadrants; the area of maximum tenderness being at or near McBurney's point. Muscular rigidity was noted over the right rectus and neighboring muscles. As his prostration and general appearance seemed to indicate a grave infection, which had already existed for upwards of fifty hours, he was removed to the Roosevelt Hospital for immediate operation. On opening the abdomen, the appendix was found to be completely gangrenous, and surrounded by an abscess containing about 30 c.c. of thin foul-smelling pus. As the gangrenous process extended to the cæcum, after removal of the appendix, the cæcal opening was closed by a purse-string suture, and the point of closure reinforced by suturing a small appendix epiploica and a layer of omentum over the stump. A large cigarette drain was left *in situ*, and the peritoneum, muscles, and skin partly closed by layer suture. Although the anæsthesia was satisfactory and the operation of short duration, the following day the temperature rose to 104, the pulse to 120; and the patient seemed gravely ill. There was, however, abundant drainage from the deep sinus necessitating frequent changes of the dressings.

On the third day, the cigarette drain was removed, and a rubber tube inserted, through which the wound was frequently irrigated and treated by the Carrel-Dakin method. The discharge from the deep cavity promptly diminished, soon ceased, and the sinus closed satisfactorily.

During this period the temperature gradually declined and the patient's condition improved; and at the end of a week, he seemed thoroughly convalescent and no further anxiety was entertained regarding his ultimate recovery.

On the seventh day after operation a peculiar deep purple œdema was noted around the points of entrance of the three upper silkworm gut sutures. These were removed, the cutaneous wound opened and packed with sterile gauze. Two or three days later to our surprise, the purple areas had not subsided, but apparently had extended to the margin of the then freely open cutaneous wound. They resembled six small carbuncles with beginning necrosis of the epithelial layer. Also it was noted that the edges of the wound beneath these lesions was undermined and presented isolated areas of white slough, which extended down to various levels in the subcutaneous fat. Incisions were later made into these areas of necrosis, and the entire wound packed loosely with gauze covering several Carrel-Dakin tubes, and was constantly treated with accurately prepared Dakin fluid. The original sloughs gradually separated, but beyond this loss of tissue,

there appeared an extending zone of the deep red œdema, which formed an elliptical area of discolored skin about the size of a human hand.

As it was evident that the Carrel-Dakin treatment failed to control the process, a number of other antiseptic agents were tried including iodine, iodoform, various mercuric compounds, hot poultices, and finally exposure of the wound to X-rays, Alpine light, and the direct rays of the sun. None of these seemed to have the slightest effect on the slow progress of the disease, which gradually extended peripherally and sloughed centrally, until there was an ulceration which extended from a point near the iliac crest, to a point half-way to the lower costal border, and well over toward the median line, making an oval sloughing ulcer about 15 to 16 cm. in length by 10 or 12 cm. in width.

During the three weeks which had elapsed since the operation, the abdominal sinus had closed, the patient was practically afebrile, had a fair appetite, and seemed constantly improving. The only major complaint being, the intense pain which was occasioned by the dressings and any manipulation of the wound.

During the latter part of this period he was seen by perhaps six or eight members of the staff, including general surgeons, experts in dermatology, bacteriology, and internal medicine; none of whom had ever seen a similar lesion arising from an operative wound

Numerous cultures were made from the tissues and wound secretions, as well as blood tests, to exclude syphilis, tuberculosis, blastomycosis, and other rare forms of infection. The wound cultures contained a large variety of organisms, but led to no definite conclusions.

At last, as it seemed evident that unless something far more radical were done in the way of treatment, a large part of the integument of the abdominal wall would be destroyed, it was decided to give a general anæsthetic and to circumscribe the entire diseased area, well beyond the lesion by an incision through the skin and entire thickness of the subcutaneous fat to the sheath of the rectus and aponeurosis of the external oblique muscles. This was done, and the long elliptical incision packed with gauze wet with a 1 per cent. solution of formalin. This was changed every day at first under gas anæsthesia, and the packing kept constantly wet with the same solution.

The sloughing process continued from the original edges of the ulcer toward the incision, but never passed this barrier; and when all the intervening tissues were destroyed, we had an extensive granulating surface with healthy edges, which quickly took on the normal process of repair. We hesitated to advise a skin graft on account of the doubtful nature of the process, and a very definite fear on the part of all who had observed its ruthless progress, lest any such procedure might again favor its reappearance.

By simple dressings and sun exposures, cicatrization took place rapidly, and at the end of thirteen weeks, the patient was discharged cured.

Shortly after the experience just related, there appeared in *Surgery, Gynecology and Obstetrics,* the report of a similar case by Dr. Thomas S. Cullen of Baltimore, admirably illustrated by two colored plates of the lesion. From Doctor Cullen's description of the etiology, symptoms, progress and wound appearances, I was convinced that our two cases represented examples of a rare but definite type of wound infection, probably due to some organism derived from the intestinal canal, as both arose from the operative treatment of a perforated intestinal lesion.

Case II.—L. M., male, sixty-four years of age, although his appearance and athletic vigor would give one the impression of a much younger man. December 18, 1925, he was admitted to the Presbyterian Hospital for operation for acute appendicitis. The duration of his illness had been about thirty hours. On admission his temperature was 100.8, pulse 110; abdomen moderately distended with marked tenderness and muscular rigidity over the appendix area.

On operation, the appendix was found to be partly gangrenous, perforated and surrounded by a collection of thin odorless sero-pus. The intestines in the immediate neighborhood were reddened and covered with fibrin. The appendix was removed, the wound partly closed, and a large cigarette drain introduced which extended to the region of the appendix stump. He reacted favorably from the operation, the abdominal symptoms subsided, the temperature and pulse improved; and his general condition at the end of three days seemed entirely satisfactory.

On the fifth day small areas of necrosis were observed around the points of entrance

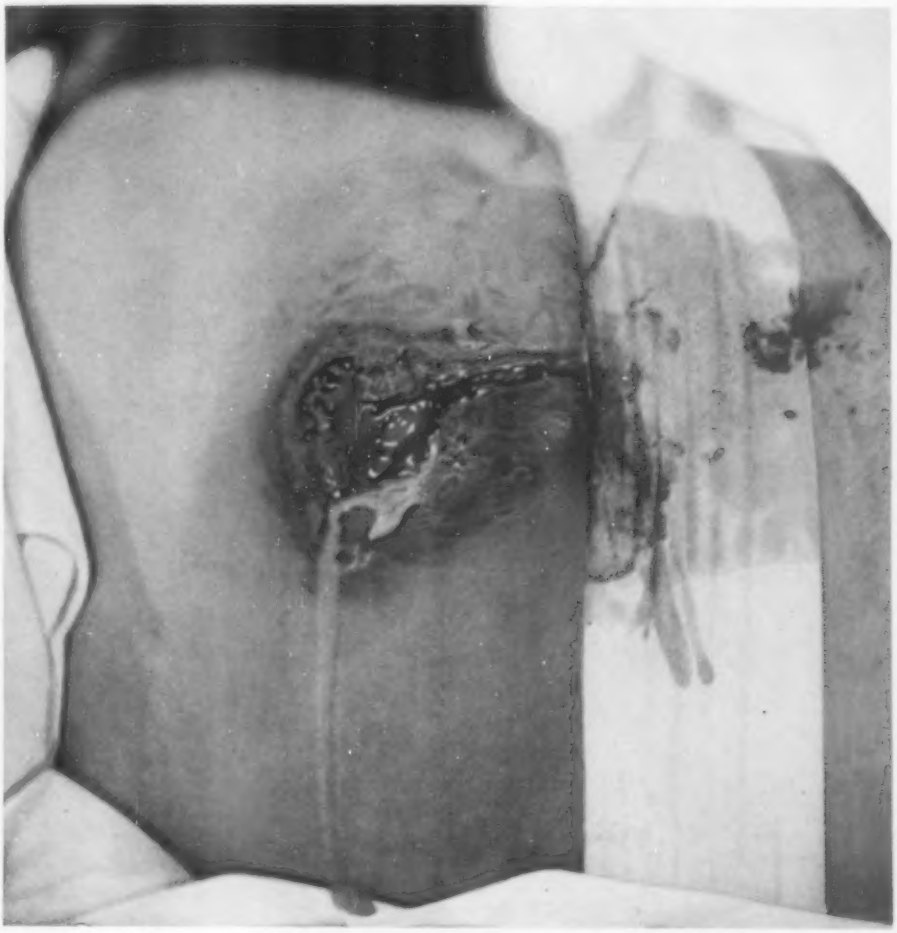


PLATE A.—Appearance of the wound before the second excision; the lower granulating portion of the incision being drawn together by adhesive plaster.

of the upper two deep silkworm gut sutures. The stitches were removed, the wound edges separated, and the wound lightly packed with gauze. The Carrel-Dakin method was employed, which at first seemed to act favorably, as for four or five days the wound showed no further changes. It did not then occur to the writer, that we had to do with other than a trivial secondary infection of the superficial wound. The deep drain was removed on the sixth day, and a small rubber tube substituted, and the deep wound frequently irrigated. About the tenth day, after the deep drainage sinus had ceased discharging, and the lower part of the wound seemed normally granulating, the same deep red discoloration and œdema, as in Case I, appeared around the upper part of the

wound with four or five oval elevated lesions at the sites of the stitch openings. There was also noted a subcutaneous area of white slough, which extended from the edges of the wound upward beneath the unbroken but œdematous skin, toward the stitch openings. A day or two later, two or three of these necrotic areas were removed, leaving an irregular undermined unhealthy looking skin border. At this time also, it was noted that the deep purple œdematous nodules showed signs of breaking down, and that the area of hyperæmia was extending outward into the surrounding skin. One or two black areas were also seen along the skin margins. It was then recognized for the first time, that we had to do with the same type of spreading gangrenous cellulitis and dermatitis as in the first case.

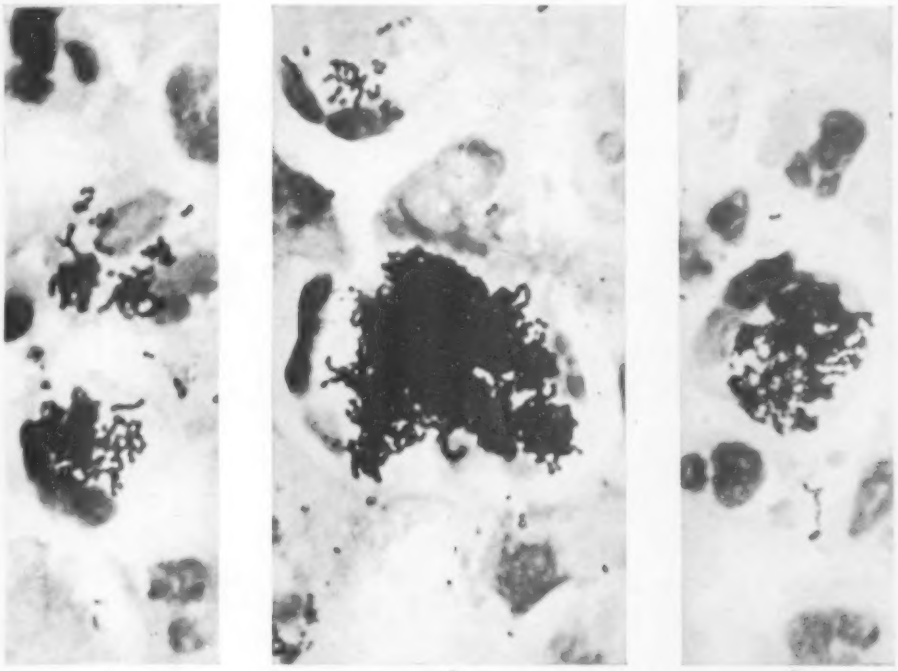
FIG. 1.—The excised lesion after formalin fixation. The figures indicate where cultures were taken.

January 9, under gas oxygen anæsthesia, the entire cutaneous margin of the wound was excised, including all of the reddened and œdematous tissues, the wound treated with peroxide of hydrogen, douched with sterile water, and packed with gauze soaked in and kept moist with Dakin solution. The process seemed arrested for two or three days; but later the same characteristic deep purple lesions occurred along the cutaneous borders, and sloughing of the fatty tissue was apparent. Both the red œdema and the subcutaneous necrosis spread more rapidly than at first, in spite of the most careful Carrel-Dakin technic; and the patient showed a definite increase in temperature and pulse rate. (Plate A.)

We were then convinced that the first excision had not been sufficiently wide to insure removal of the deeply imbedded organisms, which evidently had penetrated into the tissues well beyond the outermost limits of the hyperæmia and œdema. Again under gas-oxygen anæsthesia on January 18, a wider excision was made from 3 to 4 cm. from the wound edge. This time removing the entire wound and surrounding skin. The floor of the large wound thus created was treated by peroxide of hydrogen, douched with

sterile water, and packed with one per cent. wet formalin gauze as in the first case. This was kept in place for two days, and constantly wet with the dilute formalin solution. The formalin was then discontinued and the regular Carrel-Dakin treatment carried out. This served to arrest the process, no further characteristic lesions appeared on the skin edges, and the entire wound took on a healthy granulating appearance.

The patient was discharged from the hospital at the end of seven weeks, and later at his home continued treatment by exposure to the sun, and the use of other stimulating measures. Dating from the last operation, the time required for the healing of this extensive wound was about eleven weeks. It occurred without the aid of skin grafts.



A C B

FIG. 2.—A. Phagocytes containing a few chains of cocci. B. A phagocyte distended with organisms. C. Tangled chains of organisms with cellular fragments in the neighborhood. Gram stain. Oil immersion lens.

As in my first case, the one most distressing symptom was the acute sensitiveness of the wound, making dressings and all manipulations about the lesion extremely painful.

It is worthy of note also that as soon as the specific infection was killed, this sensitiveness promptly disappeared.

Since the observation of my second case, four other similar cases have been brought to my attention.

The first of these was a woman, sixty-three years of age, who was admitted to the Presbyterian Hospital in January, 1919, for observation. Four or five months before her admission, what was thought to be a cold abscess was present in the upper right quadrant of the abdomen. This was opened and drained. Shortly after the operation, there occurred a slowly spreading gangrenous ulceration of the skin, beginning at the wound edges, and extending in all directions, until, at the time of her admission to the hospital, the ulcerated area occupied a large part of the upper half of the abdomen, and extending well down into the right flank.

The process had been exceedingly slow, and at first was thought to be due to syphilis, tuberculosis, or one of the mycotic infections. Each of these, however, was excluded by careful tissue examinations, bacterial cultures, and inoculation experiments. The cultures from the tissues and wound secretions showed a large variety of organisms, but no definite conclusion was reached. Although the origin of the original abscess, whether mural, or intra-abdominal and possibly due to a small perforative lesion, could not be ascertained. Doctor Whipple, who saw the case several times in consultation, informed me that it was similar in many respects to my second case.

The second was one reported at the joint meeting of the New York and the Philadelphia Surgical Societies during the past winter by Dr. E. G. Alexander. His case also followed operation on an acute perforative appendicitis. The progress of the case was similar to the two reported in this paper, and although he strongly advised complete excision of the area, the patient refused operative treatment, with the result that the ulceration continued to extend until it involved a large part of the right half of the abdominal wall, the right buttock and thigh to the knee. His patient was in the hospital eleven months. The other two cases were, one reported by Dr. Christopher, of Chicago, and another which occurred in the service of Dr. A. V. Moschcowitz, of New York.

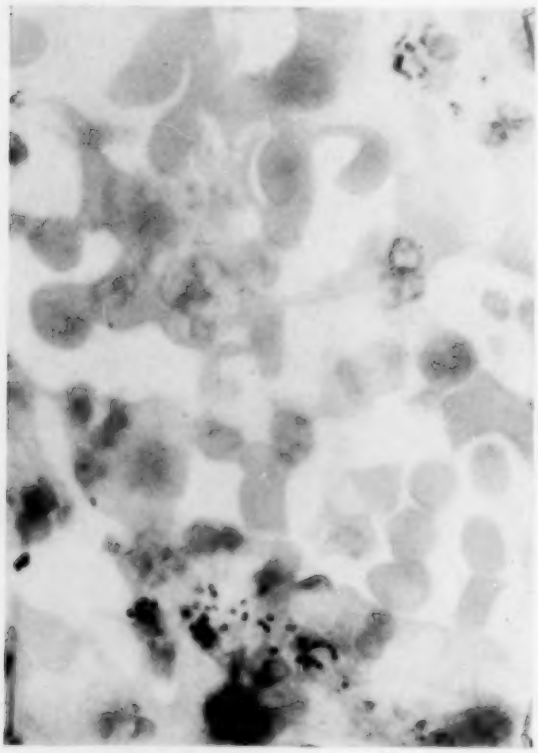


FIG. 3.—Organisms in tissue section. Gram stain. Oil immersion lens.

As soon as I recognized that the process in my second case was the same as in my first patient, I called in consultation Dr. Frank Lamont Meleney of the Surgical Staff of the Presbyterian Hospital, who is particularly interested in surgical infections, with a view to obtaining his advice and coöperation in determining the causative organism or organisms. He observed the patient from time to time, and entered enthusiastically into the plan of establishing the bacteriology of the process. The report of his observations and inoculation experiments is as follows.

Bacteriological and Experimental Study.—The fluid from the peritoneal abscess was cultured in the usual way by a member of the laboratory staff. A pure culture of non-hæmolytic streptococcus was reported. No anaërobic cultures were made and it is not on record whether or not the culture grew in the usual manner on the surface of a blood agar plate. It therefore remains an open question whether this organism was or was not the same streptococcus which is to be described below. Later, when the gangrene developed in the wound, a second routine aërobic culture revealed a hæmolytic staphylococcus aureus and a diphtheroid bacillus. The streptococcus was not found.

Subsequently a special study was made of the slough from the wound. A hæmolytic staphylococcus aureus and a diphtheroid bacillus were found again aërobically, while the anaërobic blood agar plates revealed a streptococcus which would not grow on the aërobic plates.

When the region was prepared for complete excision, the surface was painted copiously with iodine in order to minimize surface contamination. A culture was taken of the blood drawn by the first incision (at point 1 in Fig. 1). After excision, the complete specimen was taken in a sterile towel to the laboratory, the surface was again painted with iodine and incisions were made just beyond the gangrenous margins of the ulcer at points 2, 3, 4 and 5 in Fig. 1. Direct smears of the tissue fluid in these regions showed, in the two nearest the margin, great numbers of very small cocci growing in masses of tangled chains. Many of these were found to be contained in leukocytes (Fig. 2a), some stretching the cell membrane almost to the bursting point (Fig. 2b), and others in masses much larger than the phagocytes with cellular débris in the neighborhood (Fig. 2c). These findings seemed to represent different stages in the battle between the foreign invaders and the host, with apparent demonstration that the organisms were not only growing in the tissues, but in the phagocytes as well. In the two regions farther from the margins, diplococci and short chains were found both within and without the tissue cells and wandering cells. Sections of the tissue stained for bacteria revealed them in great numbers (Fig. 3). Cultures were made from the five points mentioned above, aërobically and anaërobically on five per cent. sheep blood agar plates and in cooked meat medium with and without dextrose. In twenty-four hours three out of four of the cultures yielded, in pure culture, a non-hæmolytic streptococcus which grew in the cooked meat medium with or without dextrose, both aërobically and anaërobically. On the blood agar plates, however, it failed to grow except under anaërobic conditions, the aërobic plates being without any evidence of growth. The fourth culture showed beside the streptococcus a few colonies of non-hæmolytic staphylo-

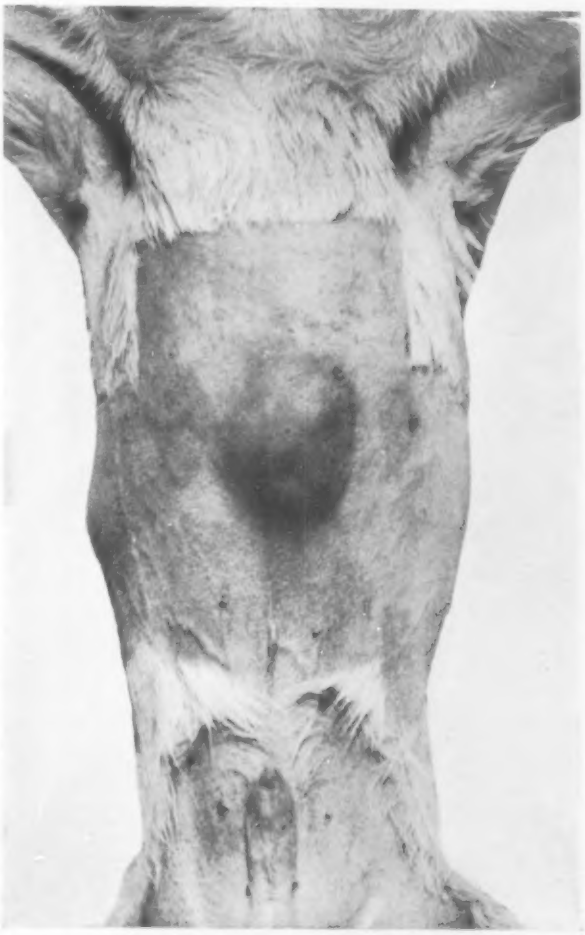


FIG. 4.—The lesion in a dog, as it appeared on the fourth day. On the left side of the picture is the swelling produced by the staphylococcus alone. On the right is the swelling produced by the streptococcus alone. In the centre is the lesion produced by the combination, showing early gangrene. One-half life size. Slightly reduced.

coccus albus on the anaërobic plate, possibly an air contamination. After forty-eight hours the culture of the blood from the incision revealed a pure culture of the same streptococcus. Thus in four out of five cultures from regions extending from just outside the margin of the ulcer to the limits of excision, this organism was found in pure culture, evidently growing in the tissues and successfully combating the defensive efforts of the host. The evidence seemed to be strong that this bacterium was in some way related to the disease process. Contrary to expectation, the hæmolytic staphylococcus aureus and the diphtheroid bacillus cultured from the slough, were not found in the zone outside of the gangrenous margin. This we considered to be most significant because it indicated that for the infection as a whole the streptococcus was the more important. Experiments were then carried out in order to determine the cultural characteristics and the pathogenicity for animals of this streptococcus.

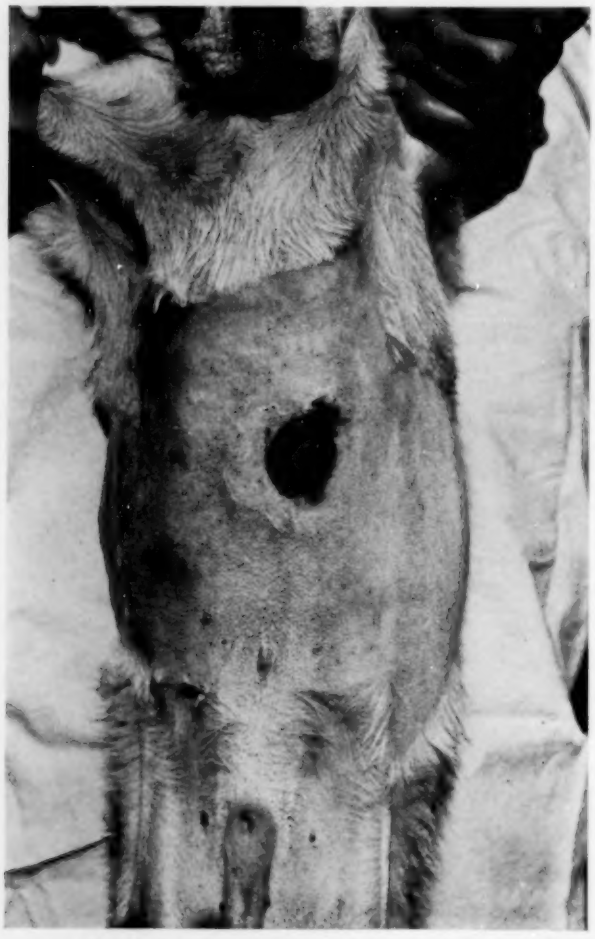


FIG. 5.—The lesion in the same dog on the sixth day. One-half size slightly reduced.

Cultural Characteristics.—It is a very small coccus growing in chains of varying lengths. The individuals are approximately 0.2–0.5 microns in diameter. It is Gram-positive. It grows readily in the anaërobic jar in cooked meat medium with two-tenths per cent. dextrose. In this medium it tends to form tangled chains in a manner similar to its growth in the tissues. It develops much less readily aërobically in the cooked meat medium with dextrose. Anaërobically on five per cent. sheep blood agar plates in twenty-four hours it grows with small pin point non-hæmolytic colonies which become slightly green on standing in the air. (Aërobically it would not grow on the blood agar plates until it had been passed through nine aërobic subcultures in cooked meat medium. It then very slowly developed minute colonies. This ninth subculture was sealed and kept for a month in the ice box. It was then found to have lost its ability to grow aërobically on the blood plates.) When grown anaërobically this organism will ferment dextrose, lactose, saccharose and salacin, but not mannite. It is killed in fifteen minutes when heated to 60° C. The organism may, therefore, be classified as a non-hæmolytic micro-aërophilic streptococcus, similar in many respects to certain of the intestinal streptococci. The intestinal origin of the streptococcus in this case is not proven; it is only presumptive.

Animal Inoculation.—Two cubic centimetres of a twenty-hour culture in cooked meat medium with two-tenths per cent. dextrose injected into the peritoneum of a mouse failed to kill. Five cubic centimetres in the peritoneum of a guinea-pig failed to make the pig ill, but the organism was recovered from the peritoneum after two weeks and, in another instance, a month later. When the ninth subculture mentioned above had acquired the faculty of growing on aërobic plates, it was injected into the peritoneum of a guinea-pig. It was recovered after twenty-four hours and was then found to have lost the faculty for aërobic growth. Five cubic centimetres subcutaneously in guinea-pigs and rabbits produced slight redness and swelling which appeared on the day after injection, but rapidly subsided. There was never any evidence of gangrene. These failures to demonstrate pathogenicity for animals seemed to controvert the very definite evidence of activity in the tissue of the patient. It was then suggested to try the effect of this organism combined with the hæmolytic staphylococcus aureus and the diphtheroid bacillus with which it was found associated in the actual gangrenous margin of the wound. Two cubic centimetres of a twenty-hour culture of each organism were injected subcutaneously into control guinea-pigs and into another pig one cubic centimetre of the hæmolytic staphylococcus aureus was combined with the same quantity of the non-hæmolytic micro-aërophilic streptococcus. In still another pig the streptococcus was combined with the diphtheroid bacillus. In twenty-four hours the staphylococcus combined with the streptococcus had produced a large, red, tender swelling two by three centimetres in diameter with a central area of discoloration indicating beginning gangrene. The staphylococcus alone produced a somewhat smaller, red, tender swelling, without any evidence of gangrene. The streptococcus alone produced only a slight red swelling, as did the combination of streptococcus and diphtheroid bacillus. The diphtheroid bacillus alone produced no lesion.

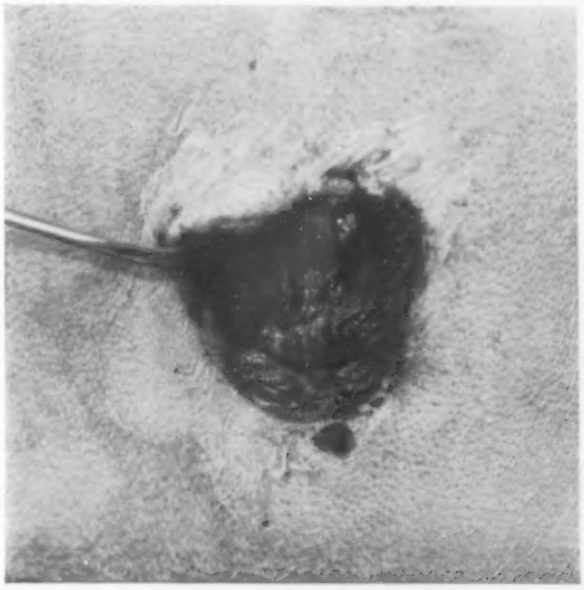


FIG. 6.—The lesion in the same dog on the seventh day, showing undermining. Life size. Slightly reduced.

In the second twenty-four hours the lesion with the staphylococcus alone increased slightly in size but thereafter subsided, finally localizing as a small abscess from which the organism was recovered after two weeks. The lesion produced by the combination of staphylococcus and streptococcus increased in the second twenty-four hours and a large irregular area of frank gangrene developed which separated at the margin after five days and sloughed out. Both organisms were recovered from the lesion. This experiment was repeated twelve times in guinea-pigs and rabbits and in every case but one produced a large lesion with more or less gangrene. The lesion in one of the guinea-pigs is shown in Figs. 7 and 8. In one rabbit the mixture produced no gangrene but an abscess formed three times the size of the controls. In one instance a silkworm gut suture contaminated with the staphylococcus was passed through an area into which the streptococcus had been injected, and it was tied with moderate tension. Gangrene

developed around the suture with a wide zone of swelling outside of it. The process generally reached its peak in three to four days, and thereafter subsided. It did not spread progressively as in the human case. On three occasions out of nine the staphylococcus, when injected alone twice in a double dose and once in a single dose in small pigs, produced some superficial gangrene, but in six cases it simply formed a small abscess. Because of this occasional inconsistency, the experiment was repeated in a dog in order to use an animal with thicker skin and more subcutaneous tissue. On the right side the staphylococcus was injected alone, on the left side the streptococcus alone and in the centre the same quantity of these two, mixed together. A total volume of five cubic centimetres was injected into each area, the pure cultures being diluted with broth. Care was taken to put each injection into the subcutaneous tissue with a minimum of trauma at the point of injection. In twenty-four hours a moderate swelling appeared at the site of the staphylococcus injection and a slightly larger one at the site of the combination. Only slight swelling appeared where the streptococcus was injected alone. In four days the mixture had produced a large swelling four times as large as the staphylococcus alone and there was an irregular patch of early gangrene in the centre. The staphylococcus lesion thereafter subsided without gangrene.

FIG. 7.—The lesion produced in a guinea-pig by a mixture of the streptococcus and the staphylococcus after forty-eight hours. The light areas in the centre are yellow dead skin. Life size. Slightly reduced.

On the the fifth day frank gangrene developed at the injection site of the mixture and on the sixth day it sloughed out, leaving an undermined gangrenous margin. This spread slightly for a day or two and then subsided, but showed very little tendency to heal. The dog died of pneumonia on the eighteenth day after inoculation. Stages of this process are shown in Figs. 4, 5, and 6. The similarity of Figs. 1, 6, and 8 is striking.

Comment.—Although no definite conclusions can be drawn from these experiments, there seems to be evidence that in guinea-pigs and in rabbits and in the only dog in which the experiment was tried the non-hæmolytic microäerophilic streptococcus and the hæmolytic staphylococcus aureus cultured

from the patient's wound, when injected together produced gangrene almost invariably, while these organisms injected separately did not—the streptococcus never and the staphylococcus only rarely in small guinea-pigs. These experiments suggest that a certain symbiotic function or a combination of functions of these two organisms may be necessary for the production of the gangrene. The rarity of its occurrence clinically may be explained by the necessity for the coincidence of two such organisms in the wound. The streptococcus is much more rare in its occurrence than the staphylococcus aureus and might easily be overlooked in routine cultures.

FIG. 8.—The lesion in the same-guinea pig after six days. There has been a slight spread involving the umbilicus. Life size. Slightly reduced.

Which organism is the essential one in the production of gangrene is a question not yet fully answered. In this patient the streptococcus was found more extensively invading the tissues while the staphylococcus was only present in the gangrenous margin. When the gangrenous margin was partially excised, the process continued to spread, but when it was completely removed, the process ceased. Even though the cut margin yielded a growth of the streptococcus, the body took care of the infection which remained. In animals the staphylococcus produced the greater lesion when injected alone, but on one occasion a mixture of the streptococcus with a control hæmolytic staphylococcus aureus produced an extensive gangrenous lesion, while the staphylococcus from this case mixed with the diphtheroid bacillus produced no gangrene. We favor the following explanation for the phenomenon. *The infection with streptococcus prepared the way for gangrenous process, but for its actual production a second organism was necessary—in this case the staphylococcus aureus.*

The solution of this problem will require more extensive experimentation The reaction of laboratory animals to infection is often so different from that of human beings that it is important to take every opportunity to study this condition as it exists in man. These cases are so uncommon that it is not likely that one person would have the opportunity to study such a condition more than once or twice. Our findings are reported in detail in order that they may be compared with similar studies made by other observers. It will be of interest to search for such a combination of organisms in other lesions of this kind for it is only by repeatedly finding these conditions prevailing, that we can be certain that the cause of the disease has been demonstrated. It is not unlikely that such combinations were present in the cases previously reported by Cullen of Baltimore, Christopher of Chicago, Alexander of Philadelphia, in the case observed by Moschcowitz of New York and in the first case seen by Doctor Brewer.

REFERENCES

[1] Cullen, Thomas S.: A Progressively Enlarging Ulcer of the Abdominal Wall Involving the Skin and Fat Following Drainage of an Abdominal Abscess Apparently of Appendiceal Origin. Surgery, Gynæcology and Obstetrics, vol. xxviii, pp.579–582, May, 1924.

[2] Christopher, F.: Severe Spreading Carbuncular Infection of Chest Wall Following Rib Resection Under Local Anæsthesia. S. Clin. N. A., vol. iv, pp. 795–810, June, 1924.

[3] Alexander, E. G.: Personal Communication.

[4] Moschcowitz, A. V.: Personal Communication through his assistant, Dr. Percy Klingenstein.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting Held April 5, 1926

The President, Dr. Charles F. Mitchell, in the Chair

COMMINUTED FRACTURE OF HUMERUS

Doctor A. Bruce Gill presented an adult man, who, October 9, 1925, sustained a comminuted fracture of the middle third of the left humerus. The two portions of the shaft were separated from each other about one inch and were overlapping for an equal distance. A third large fragment of bone about four inches long, consisting of more than half of the circumference of the shaft, was separated from the two fragments of the shaft by three-fourths of an inch to an inch.

The man was put to bed. His arm was placed on a Thomas splint with abduction of the shoulder to a right angle and with elevation of the arm so that the hand was higher than the shoulder and about ten pounds of weight were applied gradually. The fragments gradually came into better position and all the shortening was overcome. The fragment which lay free of the other two approached the main body of the shaft. Swelling of the hand and arm rapidly subsided.

After three weeks, at the end of which time union was becoming firm, a removable plaster splint was applied and patient was allowed to get up. Baking and massage of the arm and passive manipulation of the elbow were begun. By December 4 he had fairly firm union at the site of the fracture, and had about thirty degrees of motion in his elbow.

January 13, 1926. Union firm. Humerus straight. Normal motion in elbow-joint. It was rather difficult by examination of the humerus to tell where the fracture had been. Slight limitation of abduction and external rotation of shoulder was present. Patient returned to work as an upholsterer.

April 5, 1926. Left upper extremity is apparently normal in every respect. Patient suffers from no pain or disability. X-ray shows firm union. Humerus straight. The large loose fragment of bone in firm union with the shaft.

The reporter believes that the early elimination of swelling by means of the elevation had much to do with the prevention of fibrous ankylosis of hand and elbow, and with the prompt return of function in the elbow after removal of the splint. Abduction in an ambulatory splint would not have given as good a result so promptly if at all. Almost all fractures of the shaft of the humerus may be treated in this way and with very satisfactory results.

Doctor John H. Jopson said regarding the case of comminuted fracture of the shaft of the humerus, treated by extension and the Thomas splint, that he felt sure that this method is very applicable to a good many fractures of the humerus. He has been using it routinely for several years in fractures of the humerus through and below the tuberosity and has used it in a comparatively large number of such cases. In every case but one, in which there was a great deal of swelling of the hand in an old woman, the results have

been excellent. The X-ray has shown the bone lined up by this simple method and union takes place with anatomical reduction. It means confinement to bed for two weeks, but the patient is no worse off than if he was up and around. After two weeks in bed, he gets the patient up and dresses the arm in moderate abduction. One cannot attribute any cases of musculo-spiral paralysis to this treatment; but there would be fewer cases with this treatment because one gets reduction this way which cannot easily be obtained in any fixed ambulatory dressing.

SEVERE COMMINUTED FRACTURE LOWER END OF RADIUS

Doctor Gill presented an adult man who was injured December 7, 1925. When seen on the following day his fingers and hand and forearm were greatly swollen. X-ray examination showed the lower end of the radius fractured in the fashion of a Colles' fracture with about one-half inch shortening. The lower fragment was split through the centre from the radial to the ulnar side. The palmar portion of this fragment was displaced upward more than the dorsal portion, and it carried with it the carpus, so that there was a slight anterior subluxation of the hand. Furthermore, this palmar portion was again split in two in a longitudinal manner. There was thus the main portion of the body of the radius and four fragments at the lower end.

December 9, 1925. Under gas anæsthesia better position of fragments was secured. The hand and arm was dressed on a plaster splint from the elbow to the metacarpophalangeal joints. Patient was put to bed and the extremity was suspended on a standard so that his hand was well above his head. Massage of the fingers was begun at once and the patient was instructed to keep rubbing them and moving them. The man returned to light work at the end of three weeks at which time he could make a good fist and had free motion in all joints of fingers and thumb. At the end of six weeks he was back at his usual labor, which is that of foreman and mechanic in a dental manufacturing establishment.

April 5, 1926. Has normal function of wrist and fingers. Has no pain or disability.

By way of contrast Doctor Gill presented a woman with fibrous ankylosis of the hand as a result of a Colles' fracture. She had been treated by anterior and posterior splints which were retained for a period of ten weeks after the injury at which time there was still fairly marked swelling of the hand and fingers. When seen by the reporter for the first time, about twelve weeks after the fracture, she still had some swelling present and had a very severe condition of fibrous ankylosis. This condition is being improved somewhat by baking and massage and gentle manipulation, but her hand will probably never be restored to normal function. Prolonged swelling of the hand almost always leads to fibrous ankylosis, and it is the most serious condition which may result from fracture at the lower end of the radius. Therefore, the surgeon's attention should always be directed to swelling if there is any present, and every effort made to eliminate it by elevation, by early baking and massage, and by splinting in such manner that the patient can from the very beginning exercise his fingers. In the presence of severe swelling, as in this case, the best method of treatment is to put the patient to bed and elevate the arm well above the head. Fibrous ankylosis is one of the most common causes of disability of the hand and may result from injury of any portion of the upper extremity from the shoulder down. It is usually, if not always, due to prolonged swelling.

FUSION OF UPPER END OF TIBIA AND FIBULA

DISLOCATION OF FIRST METATARSAL AT BOTH ENDS

Doctor Gill presented a man who, in October of 1925, was injured in an automobile accident. He was treated in a hospital in a nearby town.

January 23, 1926, he came to the Orthopædic Hospital because of pain in his left foot and because of inability to work. At this time there was marked swelling and thickening of the foot, marked prominence of the head of the first metatarsal on the inner side and there appeared to be displacement outward of the base of the fifth metatarsal. X-ray showed almost transverse position of the bone with dislocation at both ends. (Fig. 1.)

February 5, 1926. Open reduction. Incision along metatarsal along the inner side of the foot. A small portion of the head was excised to allow reduction of the head. The base of the metatarsal was freed of adhesions. It was then possible to place the head in contact with the phalanx of the great toe and the base in contact with the articular surface of the internal cuneiform. However, the base became redisplaced as soon as the fingers or the instruments were removed from it. The fragment of bone which had been removed from the head of the metatarsal was therefore placed between its base and the second metatarsal. This kept the base in contact with the articular surface of the internal cuneiform. Wound sutured and foot dressed in plaster. Nothing was done for the fracture of the second and third metatarsals.

March 20, 1926. Plaster case was removed and a shoe with steel shank and felt pad beneath inner side of the heel and longitudinal arch and raised in front to lift heads of metatarsals was applied.

April 5, 1926. Patient's foot is in good position and condition. Can walk freely without pain. Has returned to work.

Fig. 1.—Case 3. Dislocation of first metatarsal bones at both ends.

FUSION OF UPPER END OF TIBIA AND FIBULA FOR UNUNITED FRACTURE OF THE TIBIA

Doctor Gill presented a boy who was admitted to the Widener Memorial Industrial Training School for Crippled Children, November 18, 1921, when seven years of age. He had osteomyelitis of the left tibia with pathological fracture at the junction of the upper and middle thirds. Non-union was of more than three years' duration. He had had two bone-graft operations which had failed to produce union of the tibia. On his admission he had two discharging sinuses over the left tibia and there was an inch shortening.

The sinuses healed up several months after his admission, and he was fitted with a brace on which he walked until the time of the operation now to be described.

March 9, 1923. Operation—*fusion of the upper end of tibia and fibula.* Incision between the head of fibula and tibia. Peroneal nerve identified and retracted. Fibula exposed. Periosteum split and lifted from the fibula from

just below the epiphyseal line to the junction of the upper and middle thirds. Fibula then divided below the epiphysis. The tibialis anticus muscle detached from the upper portion of the tibia and a groove cut in the tibia to receive the fibula. The distal fragment of the fibula was passed through the muscles intervening between the fibula and tibia and placed securely in the bed in the tibia which had been made for it. It was held in place by catgut sutures and by hyperextension of the knee. Dressed in plaster. Wound closed without drainage. Patient walked in the plaster case at the end of six weeks. Case removed at the end of three months. X-ray made then showed fusion of the fibula and tibia and union of the two fragments of the tibia. Later X-rays show continued growth of the tibia at the site of the old fracture and solid fusion of the upper end of the tibia and fibula with growth of the upper end of the fibula from the strip of periosteum which connected the head with the shaft like a bridge.

The surprising feature of this case is the fact that the tibia reunited at the site of the old fracture, although at the time of operation the area of non-union was not even exposed. It may have been due to stimulation of bone regeneration following the fusion operation, and that this stimulation of regeneration extended well beyond the site of the operation and was sufficient to cause new bone formation at the site of the original fracture.

TRANSPLANTATION OF UPPER END OF FIBULA TO REPLACE HEAD OF HUMERUS

Doctor Gill presented an adult man, a bricklayer, who February 16, 1921, suffered fracture of the surgical neck of his right humerus. After two months the head of the humerus was excised by the surgeon in charge because of "mass of callus about shoulder and ugly deformity."

The reporter saw him first February 23, 1922. At that time the upper end of the shaft of the humerus was one and a half inches below the acromion and the shoulder was flail. Patient was unable to abduct or elevate the arm. The upper end of the humerus would slide backward and forward in the axillary space when the patient attempted to use his arm. He had been unable to resume work at his trade as a bricklayer.

March 16, 1922. *Transplantation of upper end of fibula to upper end of humerus.* The shoulder-joint was exposed through an anterior incision. Difficulty was found in making dissection as the shoulder-joint cavity was completely obliterated. The upper end of the humerus was exposed and a place was prepared in the soft tissues beneath the acromion and against the glenoid process for the transplanted fibula. The medullary canal of the humerus was greatly enlarged and was filled with very soft substance. The cortex of the bone was extremely thin. The upper end of the humerus was sealed over with a very thin layer of bone. The upper end of the fibula, about four inches in length, was removed and inserted into the upper end of the humerus. The shaft of the fibula did not by any means fill the medullary space so that the transplant wobbled about from side to side. The head of the fibula was then placed well up beneath the acromion and well in toward the glenoid and the soft tissues which had been dissected were sutured about it to make a new capsule. Wound closed without drainage. Arm dressed in plaster case in abduction.

Case removed June 2, 1922, at which time the graft was united to the humerus.

August 2, 1922, he suffered an accident and fractured the fibula just

above its entrance into the humerus. His arm was again placed in a plaster case which was removed September 29, 1922. At that time X-ray examination showed union of the graft. After that his progress was uneventful. The graft gradually increased in thickness and strength. The patient returned to work early in 1923.

April 5, 1926. X-ray shows that the fibula has increased to about one inch in thickness, but a little less than the thickness of the humerus itself. The head of the fibula does not seem to alter much in shape as it has not become rounded off like the head of the humerus. The upper end of the humerus has increased greatly in density and in thickness of the cortex. The transplanted fibula can still be seen lying within the medullary canal. The man has been doing hard work and suffers no pain or disability in his shoulder. There is considerable flattening below the acromion. This may be due in part to wasting of the deltoid and in part to the fact that the head of the fibula is not as large as the normal head of the humerus. He can abduct his arm about seventy or eighty degrees. There is passive abduction to about a hundred and ten or a hundred and twenty degrees. External rotation fairly well beyond the sagittal plane.

PATHOLOGICAL FRACTURE OF HUMERUS IN INFANT TWO MONTHS OF AGE DUE TO CONGENITAL SYPHILIS

Doctor Gill presented a female infant, who was first seen January 12, 1926, being then three months of age. The mother stated that a month before this when the child was about two months of age, she took her by the left arm and rolled her over as she was dressing her. She stated that no greater force or violence was used than this. Immediately thereafter the child cried when the left arm was handled, and it was noticed that she no longer moved the arm. Prior to the time of this injury the arm was apparently normal and the child moved it freely and did not cry when it was handled.

At the time of his examination the left arm of the child hung limp at its side. It made no effort to move it. It cried when the arm was handled. There was an enlargement of the lower end of the arm above the elbow which appeared to begin about the middle of the humerus and gradually increased in size toward the lower end. The elbow-joint itself was apparently not involved. This enlargement seemed to be of the humerus and tender to the touch. X-ray examination showed some absorption of lime salts in the lower end of the shaft of the humerus, together with subperiosteal thickening or new bone formation beginning about the middle of the humerus and extending downward toward the lower end. There appeared to be a transverse fracture of the shaft about two inches above the lower end without displacement. In the differential diagnosis were considered fracture, osteomyelitis, sarcoma, infantile scurvy, congenital syphilis. The history of the case, the absence of fever, the X-ray appearance all indicated pathological fracture due probably to congenital syphilis. Specimen of the child's blood was not obtained. Wassermann examination of the father was negative but strongly positive of the mother. The child was placed on anti-syphilitic treatment and in six weeks' time all evidence of lesion had disappeared clinically. X-ray showed practically complete absorption of the new subperiosteal bone, and disappearance of the line of fracture, and increased density of the diseased shaft.

PHYSICOCHEMICAL FACTORS IN THE FORMATION OF GALL-STONES

Doctor J. E. Sweet and Doctor R. C. Weimer gave a lantern demonstration consisting of a large series of slides illustrating the formation of gall-stones. Slides of the artificial stones which they had made showed a

radial arrangement closely simulating that seen in real gall-stones. This radial arrangement was produced by chilling a molten mass of cholesterol and lecithin contained in a glass ball. The apparent lamellation of gall-stones was produced by a phenomenon of colloidal chemistry known as "Liesegang's rings." The authors conclude that neither the radial arrangement of the crystals in gall-stones, nor the apparent lamellation, necessarily prove that gall-stones grow from a central nucleus.

THE SURGICAL ASPECT OF BLOOD DYSCRASIAS

DOCTOR JOHN SPEESE pronounced the *Annual Oration*, being a paper entitled *The Surgical Aspect of Blood Dyscrasies.*

Stated Meeting Held May 3, 1926

The President, DR. CHARLES F. MITCHELL, in the Chair

INTRACRANIAL DIVISION OF GLOSSO-PHARYNGEAL NERVE COMBINED WITH CERVICAL RHIZOTOMY FOR PAIN IN INOPERABLE CARCINOMA OF THE THROAT

DOCTOR TEMPLE FAY reported the case of a woman, aged forty-one years, who had been under treatment for nine months for primary carcinoma of the tongue and soft palate on the left. For three months she had had extreme pain, deep in the ear, behind the ear and in the throat. Two months before, a spheno-palatine injection relieved slightly the pain in the ear, but as the growth extended there was extreme pain, constant in character, situated over the left mastoid, behind the ear, and a great degree of difficulty in swallowing, with pain, so much so that she was unable to secure sufficient nutrition. Radiation treatments produced reactions causing severe pain to such an extent, that the patient required two grains of morphine a day in addition to allinol. There is a palpable mass in the left submaxillary region and below the left ear.

In view of the pain deep in the ear and its exacerbation on swallowing, as well as the pain in the cervical distribution, a combined cervical rhizotomy and intracranial section of the ninth nerve was undertaken on the left. The operative procedure was made possible by rectal anæsthesia, which proved sufficient to maintain a complete anæsthesia throughout the entire procedure.

The preparation of the surgical field, so as to include the ninth and upper cervical posterior roots, was accomplished by a midline incision, so as to expose the upper three cervical laminæ. After removal of the atlas, axis and part of the third cervical lamina, the upper cord was disclosed and then an incision was made at right angles to the midline incision, carrying it well to the left and almost to the mastoid, at a point sufficiently below the superior occipital ridge to avoid injury to the occipital artery, and at a level of about the lower hair line of the neck. The skin and muscles were sectioned in one block. The upper flap was then freed from its attachment to the occipital bone and then turned outward toward the ear. The occipital bone was then removed over the left cerebellar hemisphere, as far out as the ridge of the mastoid and below, along the margin of the foramen magnum, to the point of entry of the vertebral artery. A small portion of bone was removed to the right of the midline. This disclosed the dura, covering the left side of the posterior fossa and the upper three inches of its prolongation down into the spinal canal.

The dural incision, which was devised for this procedure, consisted of a fishhook-shaped opening, beginning just to the left of the midline over the upper cervical cord, extending through the circular sinus, at the level of the foramen magnum, just to the left of its bifurcation, so as to avoid the occipital sinus and obviate the necessity of ligating this structure. The incision was then carried up parallel to the occipital sinus, almost to the upper margin of the bony opening, when by a curved semicircular incision, it was carried to the left and down toward the mastoid. The dural flap was then opened, and retracted toward the left shoulder. A careful dissection of the dura from the arachnoid permitted no escape of spinal fluid. It was then possible to see the structures beneath the transparent arachnoid, and to trace by means of the spinal portion of the eleventh nerve, its course, as it proceeded upward to enter the jugular foramen. At its point of emergence, it was noted that it was immediately joined by the tenth nerve on the left, composed of several fan-shaped filaments. Just above this a small structure about the size of a match stick was recognized as the glosso-pharyngeal, also making its emergence at this point. This required elevation of the left cerebellar hemisphere, by means of a lighted retractor, and when the ninth nerve was isolated, the arachnoid was punctured, the nerve secured upon a hook and avulsed. During this moment, the anæsthetist noted a drop in the pulse rate from 125 to 80. Probably due to vagus irritation. A small amount of spinal fluid escaped through the puncture of the arachnoid, but was checked when the cerebellar hemisphere returned to its normal position. The upper two cervical roots were then isolated, crushed and destroyed, silk ligatures being placed about each. The operation was done almost entirely extra-arachnoid, and no bleeding from the outer wound reached the subarachnoid space.

The dura was carefully closed and muscles approximated carefully in layers. The patient made an uneventful post-operative recovery. The stitches were removed on the eighth day, the wound healing by first intention. The relief of pain was marked in this case. The patient no longer required morphine. The pain behind the ear completely disappeared and painful paroxysms, associated with swallowing, were also absent.

There was anæsthesia over the left posterior aspect of the scalp, below the ear, and a disturbance for pain sense even under the angle of the jaw anteriorly. The left side of the soft palate and pharynx was also anæsthetic. For the past two weeks, she has noted twinges of pain, referred to the lower jaw and into the teeth on the left, as well as sharp, shooting pains in the left ear anteriorly, and in the region of the distribution of the third division of the fifth. This will require alcoholic injection to insure complete anæsthesia in the field of the growth which has extended now so as to involve the trigeminal distribution.

The patient has been able to resume her eating, she has gained twelve pounds in weight, and is now able to continue with her radiation treatments for the condition.

It is of interest to note the nerve supply in the region of the ear. Now that it has been possible to remove the sensory supply of the fifth, ninth and cervical nerves, there still remains an area which retains sensation. This must be therefore from either the seventh or tenth.

The case is unique in the combination of cervical and glosso-pharyngeal destruction. It offers a means of further application of this type of surgery to similar conditions involving the distribution of the ninth and cervical nerves. The exposure is one which readily discloses the cerebello-pontile angle and can be accomplished, extra-arachnoid with all the post-operative

benefits from excluding blood from the subarachnoid space. The muscle section of this character in the neck is as advantageous for exposure as section of the ribbon muscles and sternocleidomastoid in cases of thyroidectomy.

The case is one of seven from his series of cervical rhizotomy, but the only one in which the ninth nerve was included, with destruction of the upper cervical posterior roots.

Doctor Charles H. Frazier said that this question of performing palliative operations on patients with inoperable carcinoma of the face and mouth is one of great magnitude. Contrary to prevailing thought, morphia is not the last word in the relief of pain and particularly so in malignant disease. The dose must be increased almost from day to day until the maximum gives little satisfaction. Meanwhile the patient's morale is lowered, he becomes demoralized, and Doctor Pancoast, in the Radiotherapy Department of the University Hospital, has had difficulty in sustaining the patient's courage sufficiently to ensure regular attendance. About three years ago he first advocated operations on the trigeminal tract in inoperable lesions of the face and mouth, and especially in carcinoma of the tongue were the results gratifying.

But he soon found, when there was secondary involvement of the cervical lymph-nodes, which in fact is the rule rather than the exception, that there was almost as much, and as distressing pain in the distribution of the cervical plexus. The pain is often referred to the back of the head and may be much more distressing than that in the trigeminal zone. On his service at the University Hospital, Doctor Grant and Doctor Fay, in an attempt to control pain not of trigeminal origin, tried the effect of cervical rhizotomy in a series of patients. In some the results were beyond expectation; the patients were quite transformed from miserable morphine addicts to a reasonable state of expectancy and freedom from pain. In two of the series the relief was not complete, but this may have been due to the extension of the disease and involvement of other sensory nerves. Still he is quite convinced that the results of rhizotomy justify the undertaking.

Doctor Fay's report of an operation for the relief of pain referred to the glosso-pharyngeal nerve reminded him of a similar operation once proposed for the relief of so-called glosso-pharyngeal neuralgia. The latter has always seemed more or less of a myth. In over 1200 cases of neuralgia about the face, he has never seen one which would fit into this category.

Finally as to the technic which Doctor Fay has employed. A unilateral craniectomy should be sufficient merely for the intracranial division of the ninth cranial nerve. Years ago with this method he found it quite feasible to expose and divide the auditory nerve at its entrance to the internal auditory meatus. Speaking more particularly, with regard to the means of exposing the suboccipital region and exposing the structures of the posterior fossa, in the Neurosurgical Clinic of the University Hospital in the fall of 1925, he adopted a modification of the so-called crossbow incision that proved eminently satisfactory. With the exception of a two- or three-centimetre cross-cut at the upper end of the major incision, merely for the convenience of ventricular puncture, only a vertical incision is made in the midline. If

the interfascial plane is followed the incision is practically bloodless. To give more ample exposure of one or the other cerebellar hemisphere, the muscle mass is bisected subcutaneously on one side, sufficiently low to avoid cutting the occipital artery. Since the adoption of this technic in cerebellar explorations, under local anæsthesia, the time of operation has been shortened, the operation is almost bloodless and can be completed with surprising freedom from any serious effect upon pulse or blood-pressure.

Doctor A. P. C. Ashhurst said that he saw this patient before and after operation. The condition is certainly vastly improved. The gain of twelve pounds in weight is sufficient evidence. But there are some patients who are in no condition to stand an operation of this kind, which may take two, three, four or five hours. He had one such patient last winter with a recurrence in the neck from an epithelioma of the lip. The recurrence was ulcerating and open and on the point of causing secondary hemorrhage. Morphine was given with no relief. The patient was awake most of the night and all day long, rocking himself in the bed in agony. Not knowing what else to do and that an operation such as rhizotomy could not be done because of the proximity of the sloughing area and the feebleness of the patient he injected alcohol in the paravertebral region, aiming to hit the upper cervical nerves. He did not have much confidence in its effect, but the next day found that the patient had slept through the night without morphine. He died of secondary hemorrhage a few days later, but he had had some comfort and relief. This procedure should be considered as a possible treatment in desperate cases.

Doctor Temple Fay said that the operation required five hours. The patient was operated on entirely under rectal anæsthesia, and was completely unconscious three out of the five hours. She just became conscious as the final sutures were put in place.

As to the procedure outlined by Doctor Ashhurst, that is alcoholic injection of the cervical nerves, he had seen it used in the thoracic region, but not in the cervical region. He has had no experience with it and has always had a great deal of fear of encountering the vertebral artery, which lies close to the point of injection.

One patient out of the seven died ten days following operation from pneumonia.

TOTAL THYROIDECTOMY WITH TRANSIENT RECURRENT LARYNGEAL PARALYSIS

Doctor Irvin M. Boykin presented a woman, aged thirty-nine years, who was admitted to the Episcopal Hospital in the service of Doctor Ashhurst, September 9, 1925, complaining of a swelling of the neck and shortness of breath. The swelling was of twenty years' duration, but had rapidly increased in size during the past few months. With this increase in size there was associated shortness of breath and heart fluttering. The woman was a fairly well-nourished negress. There was no exophthalmos. Occupying the anterior and lateral aspect of the neck was a large lobulated mass, pendulous in its middle portion, and covering the upper part of the sternum.

The circumference of the neck was 65 cm. The physical examination was otherwise negative.

September 26, after more than two weeks rest in bed, a total extirpation of the thyroid was done under morphine and local anæsthesia. It was found that the gland extended substernally and in freeing the left lobe the pleura was opened; this was closed immediately. The isthmus was found densely adherent to the trachea and larynx and was freed with great difficulty. At this stage of the operation a little ether was given, as the patient could not stand tugging on the trachea. The right parathyroid gland was not found. The left was recognized and preserved.

Microscopically, the general appearance of the gland was that of cystic colloid goitre, with no evidence of malignancy.

Immediately following operation it was noticed that the patient was very dyspnœic and unable to speak above a whisper. For the first 48 hours convalescence was stormy and it was thought that a tracheotomy would have to be done. Laryngoscopic examination showed both vocal cords to be paralyzed. At the end of 48 hours the patient began to improve slowly and after two weeks was permitted to go home. Laryngoscopic examination five months later showed the vocal cords well-defined, approximation imperfect in the centre, lagging most apparent on the left side. The patient is able to speak quite well at the present time.

SARCOMA OF THE PROSTATE GLAND

Doctor Boykin reported the case of a boy, aged four years, who was admitted to the Episcopal Hospital in the service of Doctor Ashhurst, November 11, 1925, with a greatly distended bladder and unable to void. His parents stated that fifteen days prior to admission the child began to cry with pain in the abdomen, at the same time they noticed that he tried frequently to urinate and could pass but little urine.

On admission a No. 13 French catheter was passed. In passing the catheter an obstruction in the posterior urethra was encountered but overcome, 48 ounces of urine were withdrawn.

The physical examination made at this time was negative except for distention and tenderness over the lower abdomen; no rectal examination was made on admission. One week later, during which time the patient had been relieved by catheterization, it was noticed that the perineum was bulging; there was a reddened, slightly tender mass just to the left of the raphé. Rectal examination at this time revealed a mass about the size of a hen's egg in the region of the prostate. A cystogram and urethrogram done at this time showed a deviation of the urethra to the right. On December 5 an incision was made in the perineum. A bistoury was then passed into the mass. On finding no pus a finger was inserted and a few pieces of tissue resembling brain tissue were removed. The perineal incision was enlarged and the mass enucleated. The urethra was purposely not opened. The wound was packed with iodoform gauze to control bleeding.

Microscopic examination of tissue showed a sarcoma of the mixed-cell type, the round cells predominating in certain areas and spindle cells in others.

The patient did well following operation, voided freely and had normal bowel movements daily. Twenty-six days after operation, a rectal examination was made and a large firm mass was found extending from the perineum to a point as far up as the finger could reach. Patient now began having trouble voiding and could not defecate without use of enemata.

January 16, under ether anæsthesia, the perineum was reopened and a large mass of tissue removed from around the posterior urethra and base of

bladder. Bleeding was very free and controlled with difficulty, the posterior urethra and vesical neck were opened and the bladder and perineum packed with iodoform gauze. The patient left the operating room in shock, and died two hours later.

Microscopic examination of the second specimen removed was identical with that of the first.

ETHER-OIL COLONIC ANÆSTHESIA

Doctor Robert H. Ivy and Hilda Melching, R.N., read a paper with the above title.

STABILIZATION OF PARALYTIC TALIPER VARUS

Doctor Francis S. Chambers read a paper with the above title.

POST-OPERATIVE SPREADING—SUPERFICIAL GANGRENE

Doctor Emory G. Alexander reported the case of a man, aged fifty-three years, who was admitted to the Episcopal Hospital, December 23, 1924, with definite symptoms of appendiceal abscess with a history of twelve days' development.

At operation, a friable gangrenous appendix was removed from an abscess cavity near the brim of the pelvis. Pus cultures, staphylococcus. Wound closed with three cigarette drains. Severe infection of the wound edges followed, for which the wound was reopened and packed with iodoform gauze. The appearance of the area exposed closely resembled that of a carbuncle. No tendency to healing appeared during the next few weeks, despite irrigations twice daily. The infection spread through the subcutaneous fat layer, producing a progressive red indurated area about the wound, which area subsequently broke down. In spite of the employment of mercurochrome, autogenous vaccine, horse serum and the removal of sloughs, the process continued to extend. Cautery excision was advised but the patient refused. An ischio-rectal abscess developed after which the temperature fell to 99° F. and the general condition showed some slight improvement.

March 27, wound culture showed presence of staphylococcus epidermis, staphylococcus tetragenus, micrococcus buccalis, streptococcus hæmolyticus; blood culture presented micrococcus liquefaciens.

The ulcer continued to spread about four millimetres a day. Dressings of dichloramin-T failed to check the progress.

April 20, the wound was irrigated with normal salt solution. The necrotic tissue was cut away, the fragments washed away with normal saline and arkase placed around the edges of the wound.

May 20, the arkase was discontinued, and the wound was then irrigated with a weak solution of iodine. The ulceration continued to spread one-third of the way down the thigh.

June 15, direct sun rays were tried with one-half hour exposures, and gradually increased to two hours at a time.

July 1, wet dressings of phenol and bichloride were tried. A slight improvement followed. The sun treatment had now to be discontinued as it seemed to act as an irritant. Sterile milk (prepared in the hospital laboratory) was given to provide a foreign protein. Then Aolin's milk in 5 c.c. ampoules was prescribed, the first ampoule being given, hypodermically, on August 8.

August 15 there seemed to be less odor about the wound since the application of wet dressings. The Aolin milk was continued, several times a week,

and was followed each time by a slight decrease in temperature. The dose was then reduced on August 25 to one ampoule a week. The general condition began to improve, although the necrotic process went right on, but the ulcerated area behind the necrosis seemed to look better. Local dressings were continued and a 10 per cent. solution of silver nitrate solution was applied locally to the gangrenous margin instead of a 4 per cent. solution of salicylic acid which was being used until then.

October 15, 1925. The sun-ray treatment was tried again, but had to be stopped because of the irritating effect, but the patient for the last month has been able to be up and about in the hospital grounds in a wheel chair.

FIG. 1.—Doctor Alexander's case of post-operative spreading superficial gangrene.

Aolin's milk seemed to have acted favorably in stimulating his resistance. The necrotic process continued downward and on September 30 had reached to within 8 cm. of the knee. The temperature now rose to only about 99° F. each day.

October 10, there was quite a violent reaction from the Aolin's milk which was being given every seven days. Within the next ten days the necrotic process seemed to be less rapid, healing in the destroyed tissue appeared to be more prompt and epidermis was beginning to appear in places; the necrosis seemed to show signs of arrest, having reached a point on a level with the inferior border of the patella. The temperature had been normal for two weeks. Local treatment was continued, but Aolin's milk was discontinued. October 20 the infection seemed to have died out. From November 5 on improvement progressed without interruption and on November 18 the patient was discharged in good condition, being able to get about in a wheel chair. The operative wound was entirely healed. Islands of granulation covered the areas of the skin, destruction of which extended from the operative wound downward and lateralward to the anterior superior spine, over the crest of the

ileum, and down the thigh to the inferior extremity of the patella. Between these islands of granulation some few crusts were still present, but granulation was progressing. The area over the knee healed much more rapidly and thoroughly than elsewhere. The wet dressings were continued in order to facilitate the removal of the crusts and to prevent an accumulation of pus under them, and a possible reinfection.

March, 1926, the patient has entirely recovered.

The reporter added that the gangrene of the fat and skin seemed to travel in waves with periods of exacerbation of ten days, followed by more or less quiescent state of from ten days to two weeks.

The gangrenous process never involved the median side of the wound, but traveled laterally from the incision to the anterior superior spine over the crest of the ilium, down the thigh on its anterior and lateral aspects as far as the head of the fibula. (See Fig. 1.)

There never was any sign of a fecal fistula nor was there any sugar in the urine to account for the process, although on admission the blood sugar was somewhat above normal, the blood Wassermann test was negative.

The recovery took place after the infection seemed to have burned itself out which, however, was a matter of ten months.

ALKALOSIS

Doctor Frederick A. Bothe read a paper with the above title.

In response to questions he added that jejunostomy is performed in cases that do not respond to medical treatment, though abdominal distention is not present, because it not only affords a means of tiding the patient over, but also establishes drainage of toxic substances which are thought to be present in the upper gastro-intestinal tract.

Acidosis differs from alkalosis clinically in that the patients are more toxic and the air hunger syndrome becomes quite pronounced. The CO_2 combining power is lowered in acidosis and acetone bodies are found in the urine, whereas in alkalosis the CO_2 combining power is elevated and the urinary findings are those of renal damage. The blood chlorides do not fall in acidosis as they do in alkalosis.

All the primary operations were performed under general anæsthesia.

The etiology of alkalosis is not known. It is still a disputed question whether the toxæmia with the resulting alkalosis is due to a definite toxin or to toxic substances which are formed in the extensive protein destruction.

CYSTS OF THE OMENTUM

Doctor William J. Ryan read a paper with the above title.

CORRESPONDENCE

THE HISTOLOGY OF SPINAL CORD AFTER SPINAL ANÆSTHESIA

EDITOR, ANNALS OF SURGERY:

Sir:

Dr. Meredith F. Campbell's article in your July number is a very helpful contribution to disperse a considerable amount of fear, that still persists in regard to spinal anæsthesia. This, as well known, is greatly due to an unlucky demonstration before a distinguished group of surgeons in New York, 1909. With adequate precautions, exact indications and technic, its use is really to be recommended. In connection with Doctor Campbell's statement, that there are no records of autopsy performed after a spinal death to reveal the condition of the spinal cord and meninges, I would like to draw the attention to a series of thirteen autopsies published by the neuro-histologist in Munich, Spielmeyer,* as early as 1908. Stovain had been used in these cases. Six patients had received 0.05–0.07 grams, seven had doses between 0.10–0.12 grams. Only one death could be attributed to the anæsthesia, the others died from two to eight days from definite other causes, while one patient lived a year and a half after the spinal anæsthesia, without showing any nervous disturbances. If we disregard the case of stovain death, where the severe chromolytic changes of the ganglion cells were probably due to the respiratory failure and circulatory disturbances, remain *three cases*, that showed positive histological findings all of which received 0.12 grams of stovain. These showed an involvement of the large polygonal "motor" cells, which were swollen, their granula decomposed and nuclei damaged. There was no clinical evidence of any motor lesion. Spielmeyer concluded, that these changes are reparable, but they pointed to a reduction of the dose of 0.12. Since then stovain has been substituted by novocain and tropacocain, these two drugs being used now mostly for spinal anæsthesia. While several experimented studies have been carried out on animals, this series is the only one to my knowledge, that has been published in man.

With our present drugs and dosage (0.06–0.10 grams of novocain) these changes, which never caused any clinical symptoms, are not to be feared.

G. DE TAKATS, M.D., *Chicago, Illinois.*

* Spielmeyer, W.: Veränderungen des Nervensystems nach Stovain-anæsthesie. Münch. med. Wchschrift, 1908, No. 31, p. 1629.

To Contributors and Subscribers:

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